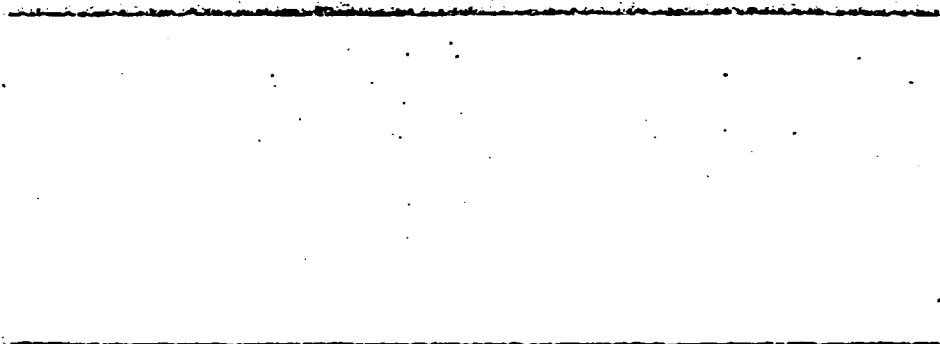


37387



Fred C. Hart Associates Inc.



DRAFT

Draft

REMEDIAL INVESTIGATION REPORT
MILLINGTON SITE
MORRIS COUNTY, NEW JERSEY

Prepared for:

National Gypsum Company
Dallas, Texas

Prepared by:

Fred C. Hart Associates, Inc.
140 Allen Road
Liberty Corner, NJ 07938

February 29, 1988

DRAFT

TABLE OF CONTENTS

<u>Section</u>	<u>Title</u>	<u>Page</u>
1.0	INTRODUCTION	1-1
1.1	Purpose of Investigation	1-1
1.2	Scope of Work	1-2
1.3	Contents of Report	1-3
2.0	BACKGROUND	2-1
2.1	Physiographic Setting	2-1
2.2	Site Description and History	2-1
2.3	Demography	2-3
2.4	Land Use	2-5
2.5	Natural Resources	2-5
2.6	Climatology	2-6
3.0	SUMMARY OF FIELD INVESTIGATIVE ACTIVITIES	3-1
3.1	Introduction	3-1
3.2	Test Borings Operations	3-1
3.2.1	Purpose	3-1
3.2.2	Methodology	3-1
3.2.2.1	Test Borings	3-4
3.2.2.2	Soil Sample Collection and Analysis	3-4
3.2.3	Findings	3-6
3.2.3.1	Subsurface Characteristics	3-6
3.2.3.2	Analytical Results	3-6
3.3	Monitor Well Installation	3-13
3.3.1	Purpose	3-13
3.3.2	Methodology	3-13
3.3.2.1	Unconsolidated Monitor Wells	3-13
3.3.2.2	Rock Monitor Well	3-16
3.3.3	Findings	3-16

TABLE OF CONTENTS (CONTINUED)

<u>Section</u>	<u>Title</u>	<u>Page</u>
3.4	Casing Elevation Survey and Water Level Measurements	3-16
3.4.1	Purpose	3-16
3.4.2	Methodology	3-17
3.4.2.1	Well Elevation Survey	3-17
3.4.2.2	Water Level Measurements	3-17
3.4.3	Findings	3-17
3.5	Engineering Analysis	3-17
3.5.1	Purpose	3-17
3.5.2	Engineering/Physical Properties	3-17
3.5.2.1	Purpose	3-17
3.5.2.2	Methodology	3-19
3.5.2.3	Findings	3-21
3.5.3	Stability Analysis	3-22
3.5.3.1	Purpose	3-22
3.5.3.2	Methodology	3-22
3.5.3.3	Findings	3-28
3.5.4	Additional Engineering Investigation	3-30
3.5.4.1	Purpose	3-30
3.5.4.2	Methodology	3-30
3.5.5	Slope Revegetation Potential	3-35
3.5.5.1	Purpose	3-35
3.5.5.2	Methodology	3-35
3.5.5.3	Findings	3-37
3.5.6	Test Pit Excavations	3-37
3.5.6.1	Purpose	3-37
3.5.6.2	Methodology	3-37
3.5.6.3	Findings	3-37
3.6	Permeability Testing	3-39
3.6.1	Purpose	3-39
3.6.2	Methodology	3-39
3.6.3	Findings	3-40
3.7	Ambient Air Sampling	3-43
3.8	Surface Water and Sediment Sampling	3-43
3.8.1	Purpose	3-43
3.8.2	Methodology	3-44
3.8.3	Findings	3-49
3.9	Groundwater Sampling	3-61
3.9.1	Purpose	3-61
3.9.2	Methodology	3-61
3.9.3	Findings	3-62

TABLE OF CONTENTS (CONTINUED)

<u>Section</u>	<u>Title</u>	<u>Page</u>
3.10	Aquatic Biota Sampling	3-78
3.10.1	Purpose	3-78
3.10.2	Methodology	3-78
3.10.3	Findings	3-81
3.10.3.1	Indicator Species and Species Diversity for all Stations . .	3-81
3.10.3.2	Site-Specific Appraisals . . .	3-83
4.0	GEOLOGY AND HYDROGEOLOGY	4-1
4.1	Introduction	4-1
4.2	Geology	4-1
4.2.1	Regional Geology	4-1
4.2.2	Site Geology	4-3
4.3	Hydrology	4-3
4.3.1	Surface Water	4-3
4.3.2	Flood Potential	4-9
4.3.3	Drainage Patterns	4-9
4.4	Hydrogeology	4-9
4.4.1	Regional Hydrogeology	4-9
4.4.2	Site-Specific Hydrogeology	4-12
5.0	EXTENT OF CONTAMINATION	5-1
5.1	Millington Site	5-1
5.1.1	Asbestos Waste	5-1
5.1.2	Surface/Subsurface Soils	5-3
5.1.3	Groundwater Contamination	5-6
5.2	Surface Water Contamination	5-8
5.3	Sediment Contamination	5-10
5.4	Source and Distribution of Contaminants	5-11
6.0	ENDANGERMENT ASSESSMENT	6-1
6.1	Introduction	6-1
6.1.1	Purpose	6-1
6.1.2	Site Description and History	6-1

TABLE OF CONTENTS (CONTINUED)

<u>Section</u>	<u>Title</u>	<u>Page</u>
6.2	Contaminants Found at the Site	6-3
6.2.1	Subsurface Soil	6-3
6.2.2	Surface Soils	6-6
6.2.3	Sediment	6-6
6.2.4	Surface Water	6-8
6.2.5	Groundwater	6-11
6.2.6	Evaluation and Selection of Indicator Chemicals	6-13
6.2.6.1	Selection of Inorganics	6-15
6.2.6.2	Selection of Organics	6-18
6.3	Baseline Risk Assessment	6-19
6.3.1	Factors Affecting migration	6-19
6.3.1.1	Regional Geology/Hydrology	6-19
6.3.1.2	Site-Specific Geology	6-19
6.3.1.3	Site-Specific Hydrology	6-20
6.3.1.4	Climatology	6-20
6.3.2	Environmental Fate	6-21
6.3.2.1	Soils	6-21
6.3.2.2	Surface Water	6-22
6.3.2.3	Groundwater	6-23
6.3.2.4	Environmental Fate and Transport of Indicator Chemicals	6-24
6.3.2.4.1	Cadmium	6-24
6.3.2.4.2	Mercury	6-24
6.3.2.4.3	Nickel	6-25
6.3.2.4.4	Bis(2-ethylhexyl)phthalate	6-25
6.3.2.4.5	Arsenic	6-26
6.3.2.4.6	Benzene	6-26
6.3.2.4.7	Trichloroethylene	6-26
6.3.2.4.8	Asbestos	6-27
6.3.3	Exposure Pathways	6-28
6.3.3.1	Soil	6-28
6.3.3.2	Surface Water	6-30
6.3.3.3	Groundwater	6-32
6.3.4	Toxicity Evaluation of Indicator Chemicals	6-32
6.3.4.1	Cadmium	6-33
6.3.4.2	Mercury	6-38
6.3.4.3	Nickel	6-39
6.3.4.4	Bis(2-ethylhexyl)phthalate	6-40
6.3.4.5	Arsenic	6-41
6.3.4.6	Benzene	6-43
6.3.4.7	Trichloroethylene	6-44
6.3.4.8	Asbestos	6-45

TABLE OF CONTENTS (CONTINUED)

<u>Section</u>	<u>Title</u>	<u>Page</u>
6.3.5	Environmental Receptor Analysis	6-46
6.3.5.1	Human Population	6-46
6.3.5.2	Floral Receptors	6-47
6.3.5.3	Faunal Receptors	6-48
6.3.5.4	Food Chain Analysis	6-49
6.3.5.5	Endangered/Threatened Species	6-50
6.3.6	Exposure Point Concentrations and Risk Characterization	6-50
6.3.6.1	Selection of ARARs	6-50
6.3.6.2	Development of Risk Characterizations	6-50
6.3.6.2.1	Direct Contact to On-Site Soil	6-51
6.3.6.2.2	Ingestion of Surface Soils	6-53
6.3.6.2.3	Ingestion of Contaminated Fish	6-60
6.3.6.2.4	Direct Contact With Surface Waters	6-62
6.3.6.3	Surface Water	6-66
6.3.6.4	Groundwater	6-66
6.3.7	Uncertainties in the Risk Management Process	6-66
6.3.8	Risk Management comparisons	6-67
6.3.8.1	Present Risks	6-69
6.3.8.1.1	Surface Soils	6-69
6.3.8.1.2	Subsurface Soil	6-69
6.3.8.1.3	Surface Water	6-69
6.3.8.1.4	Groundwater	6-71
6.3.8.2	Future Risks	6-71
6.3.8.2.1	Surface Soils	6-71
6.3.8.2.2	Subsurface Soils	6-71
6.3.8.2.3	Surface Water	6-71
6.3.8.2.4	Groundwater	6-72

REFERENCES

LIST OF TABLES

<u>Table No.</u>	<u>Title</u>	<u>Page</u>
3.2-1	Construction Details of Test Borings	3-2
3.2-2	Laboratory Analyzed Test Boring Samples	3-7
3.2-3	Summary of Inorganic Data - Test Boring Samples	3-8
3.2-4	Summary of Organic Data - Test boring Samples	3-9
3.2-5	Trace Element Content of Natural Soils	3-10
3.4-1	Casing Elevations and Water Level Measurements	3-18
3.5-1	Summary of Laboratory Test Results	3-23
3.5-2	Triaxial Compression Test Report of Asbestos Mound Millington Site	3-24
3.5-3	Consolidation Test of Asbestos Mound	3-25
3.6-1	Hydraulic Conductivity Values as Determined from Slug Test Data	3-41
3.8-1	Surface Water and Sediment Station Numbers and Locations	3-45
3.8-2	Surface Water Sample Numbers and Physical Parameters - Initial Sampling Round	3-49
3.8-3	Summary of Priority Pollutant Data - Surface Water Samples Initial Sampling	3-50
3.8-4	Applicable Standards and Criteria for Surface Water	3-51
3.8-5	Summary of Priority Pollutant Data - Surface Water Samples Second Round Sampling Results	3-53
3.8-6	Summary of Priority Pollutant Data - Surface Water Samples Third Round Sampling Results	3-54
3.8-7	Summary of Asbestos Sampling Data - Surface Water Samples	3-55

LIST OF TABLES (CONTINUED)

<u>Table No.</u>	<u>Title</u>	<u>Page</u>
3.8-8	Sediment Sample Numbers and Description	3-57
3.8-9	Summary of Organic Data - Sediment Samples . . .	3-58
3.8-10	Summary of Inorganic Data - Sediment Samples . .	3-59
3.9-1	Groundwater Sampling Parameters - Initial Sampling Round	3-63
3.9-2	Groundwater Quality Standards and Criteria - Metals	3-65
3.9-3	Groundwater Quality Standards and Criteria - Non-Metals	3-66
3.9-4	Summary of Priority Pollutant Data - Groundwater Monitoring Well Samples Initial Sampling Results	3-67
3.9-5	Summary of Groundwater Asbestos Data	3-69
3.9-6	Summary of Priority Pollutant Data - Groundwater Monitoring Well Samples Second Round Sampling Results	3-70
3.9-7	Summary of Organic Data - Groundwater Monitoring Well Samples Third Round Sampling Results . . .	3-73
3.9-8	Summary of Priority Pollutant Total Metals Data - Groundwater Monitoring Well Samples Third Round Sampling Results	3-74
3.9-9	Summary of Priority Pollutant Dissolved Metals Data - Groundwater Monitoring Well Samples Third Round Sampling Results	3-75
3.10-1	Site-Specific Species Ranking for the Whole Great Swamp System	3-84
3.10-2	Physical Characteristics of the Biological Stations	3-85
4.4-1	Hydrologic Parameters	4-15

LIST OF TABLES (CONTINUED)

<u>Table No.</u>	<u>Title</u>	<u>Page</u>
6.2-1	Trace Chemical Element Content of Natural Soils	6-4
6.2-2	Subsurface Soil Sampling Results	6-5
6.2-3	Surface Soil sampling Results	6-7
6.2-4	Sediment Sampling Results	6-9
6.2-5	Surface Water Sampling Results	6-10
6.2-6	Storm Drain Sampling Results	6-12
6.2-7	Groundwater Sampling Results	6-14
6.2-8	Ranking for Indicator Chemical Selection	6-16
6.2-9	Selected Chemical Properties of Indicator Chemicals	6-17
6.3-1	Matrix of Potential Exposure Pathways	6-29
6.3-2	Toxicity Parameters of Indicator Chemicals at the Millington Site	6-34
6.3-3	Selected Toxic Impacts of Indicator Chemicals at the Millington Site	6-36
6.3-4	Potential ARARs for the Millington Site	6-52
6.3-5	Parameters Used in Calculation of Body Dose Levels for On-site Soils	6-54
6.3-6	Direct Contact Risk Characterization Calcula- tions: On-Site Soils	6-57
6.3-7	Risk Characterization for the Ingestion of Contaminated Surface Soil	6-61
6.3-8	Risk Characterizations for the Ingestion of Contaminated Fish	6-63
6.3-9	Risk Characterization for the Direct Contact With Surface Water	6-65
6.3-10	Chemicals of Concern Which Pose Unreasonable Risks on Site	6-70

LIST OF FIGURES

<u>Figure No.</u>	<u>Title</u>	<u>Page</u>
2.2-1	Site Location Map	2-2
2.2-2	Site Map	2-3
3.2-1	Test Boring Locations	3-3
3.3-1	Monitoring Well Locations	3-14
3.5-1	Asbestos Mound Stability Analysis	3-27
3.5-2	Asbestos Mound Potential Critical Failure Surfaces	3-29
3.5-3	Site Plan	3-31
3.5-4	Natural Moisture Content vs Depth in Asbestos (Individual Boring)	3-32
3.5-5	Natural Moisture Content vs Depth in Asbestos (Composite Data)	3-33
3.5-6	Natural Moisture Content vs Unit Dry Weight (Composite Data)	3-36
3.5-7	Test Pit Locations Map Millington Site	3-38
3.8-1	Surface Water/Sediment Sample Locations	3-46
3.10-1	Biota Sample Locations	3-80
4.2-1	Cross-Section Location Map	4-4
4.2-2	Geologic Cross-Section A-A	4-5
4.2-3	Geologic Cross-Section B-B	4-6
4.4-1	Groundwater Flow Map	4-13
5.5-1	Asbestos Fill Extent-Millington Site	5-2

LIST OF APPENDICES

Appendix A	-	Test Boring Logs
Appendix B	-	Laboratory Data
Appendix C	-	Monitoring Well Construction Diagrams
Appendix D	-	Engineering Analyses
Appendix E	-	Test Pit Logs
Appendix F	-	Slug Test Data
Appendix G	-	Asbestos Sampling Results
Appendix H	-	Aquatic Biota Raw Data
Appendix I	-	Endangerment Assessment Calculations

1.0 INTRODUCTION

Fred C. Hart Associates, Inc. (HART) was retained by National Gypsum Company of Dallas, Texas to conduct a Remedial Investigation/Feasibility (RI/FS) Study of four sites in Morris County, NJ. This investigation was implemented pursuant to CERCLA Administrative Order - 50103 (the "Order") between National Gypsum Company and the United States Environmental Protection Agency (EPA) under the national "Superfund" program. EPA has identified National Gypsum Company as a potentially responsible party.

The sites are next to or close by a former National Gypsum Plant in Millington, NJ where the company produced cement asbestos roofing and siding between 1955 and 1975. These four sites consist of:

1. the Millington Site, located at 50 Division Avenue, where the former National Gypsum plant was located;
2. the former Dietzman Tract located in the Great Swamp National Wildlife Refuge in Harding Township, New Jersey;
3. the property at 257 New Vernon Road in Passaic Township, New Jersey; and
4. the property at 651 White Bridge Road also in Passaic Township, New Jersey.

The last three sites are collectively referred to as the satellite sites.

This report presents the results of that portion of the investigation carried out at the Millington Site from August 1986 through November 1987. The results of the satellite sites are presented in a separate RI Report.

2. Engineering Investigation - this particular task stressed the analysis of the physical characteristics and properties of the asbestos fill material at the Millington Site. This effort involved the construction of two test pits and the collection of thirteen shelly tube and two soil samples from an asbestos waste mound. Additional engineering studies were performed to evaluate further the slope stability of the asbestos pile. The task included more detailed topographic mapping, additional field investigation and laboratory testing and refined stability analyses based on the additional field and laboratory data.
3. Environmental Sampling and Monitoring - this task involved the sampling and analysis of a number of environmental media in an effort to evaluate the overall environmental impact and risk associated with the Millington Site. Specifically, the media of concern included groundwater, surface water, sediments and ambient air and biota.
4. Field Surveying - this task resulted in the production of base maps of the site. Data included in these maps consisted of: location of monitoring wells and test borings; boundaries of the subsurface asbestos - fill geometry; and surveyed boundaries of the Millington Site. The field survey work was performed by Azzolina and Feury, Professional Engineers of Paramus, New Jersey.

1.3 Contents of Report

This report has been divided into seven chapters. The first chapter contains introductory material pertaining to the purpose and scope of the investigation. The second summarizes background data collected prior to this investigation. A summary of the purpose, methodology and findings of all the field investigative activities is included in the third chapter. The fourth and fifth chapters summarize our current understanding of the geology, hydrology and extent of contamination at the site. Chapter 6 contains an Endangerment Assessment and Chapter 7 contains the conclusions.

2.0 BACKGROUND

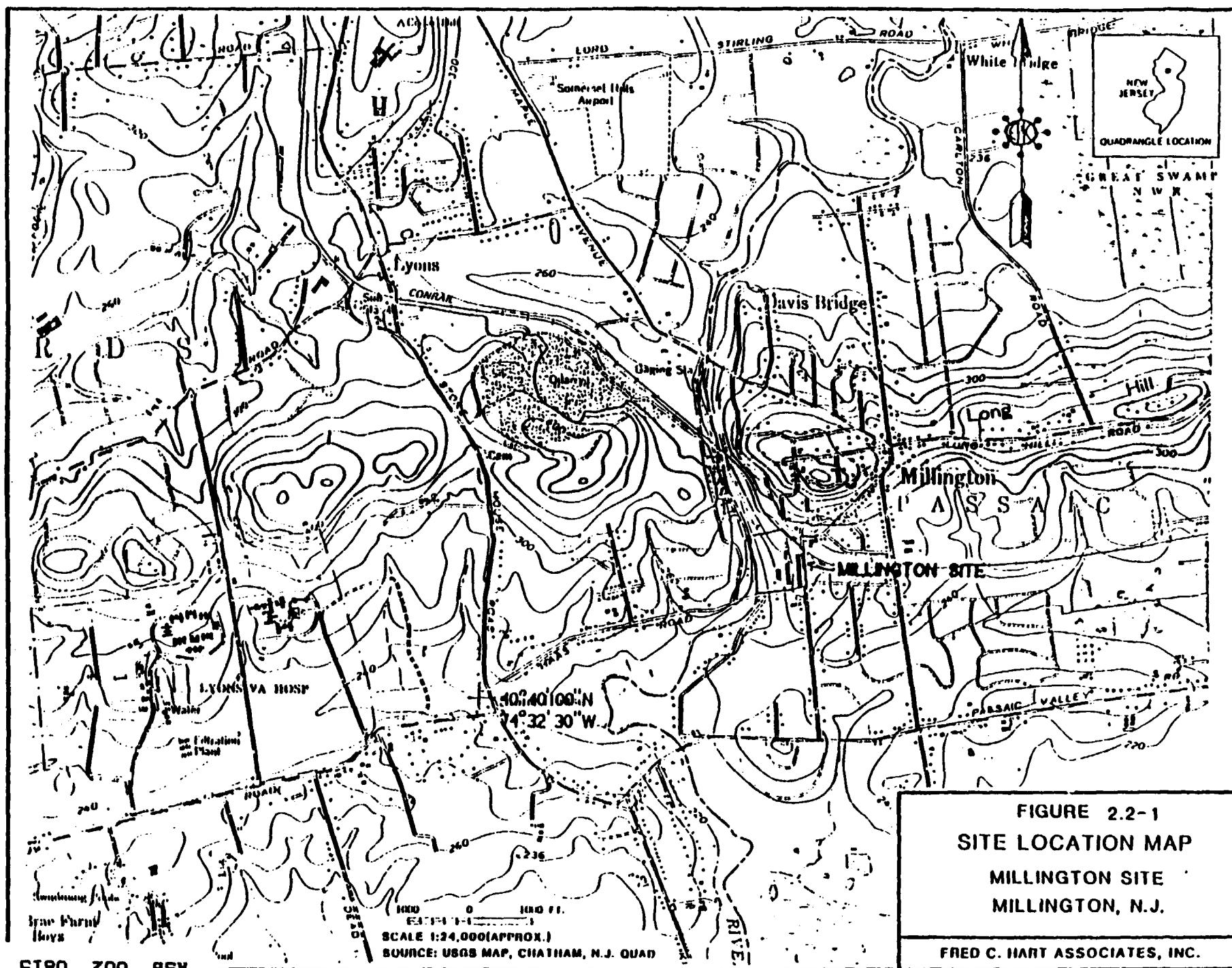
2.1 Physiographic Setting

The Millington Site is located in southeastern Morris County, within the Piedmont Physiographic Province. The site lies in a distinct topographic and hydrologic region that occupies a little more than one quarter of the Passaic River Basin. The bedrock in this part of the Piedmont Province is composed of Mesozoic Formations of Early Jurassic age. Principally, the bedrock consists of red sandstones, siltstones, and shales that are inter-fingered with basalt flows. Unconsolidated deposits of Quaternary age mantle the bedrock. These deposits consist of swamp muck and glacial deposits that vary in extent and thickness. Additional discussions describing the geology and hydrogeology in-depth are presented in Chapter 4.

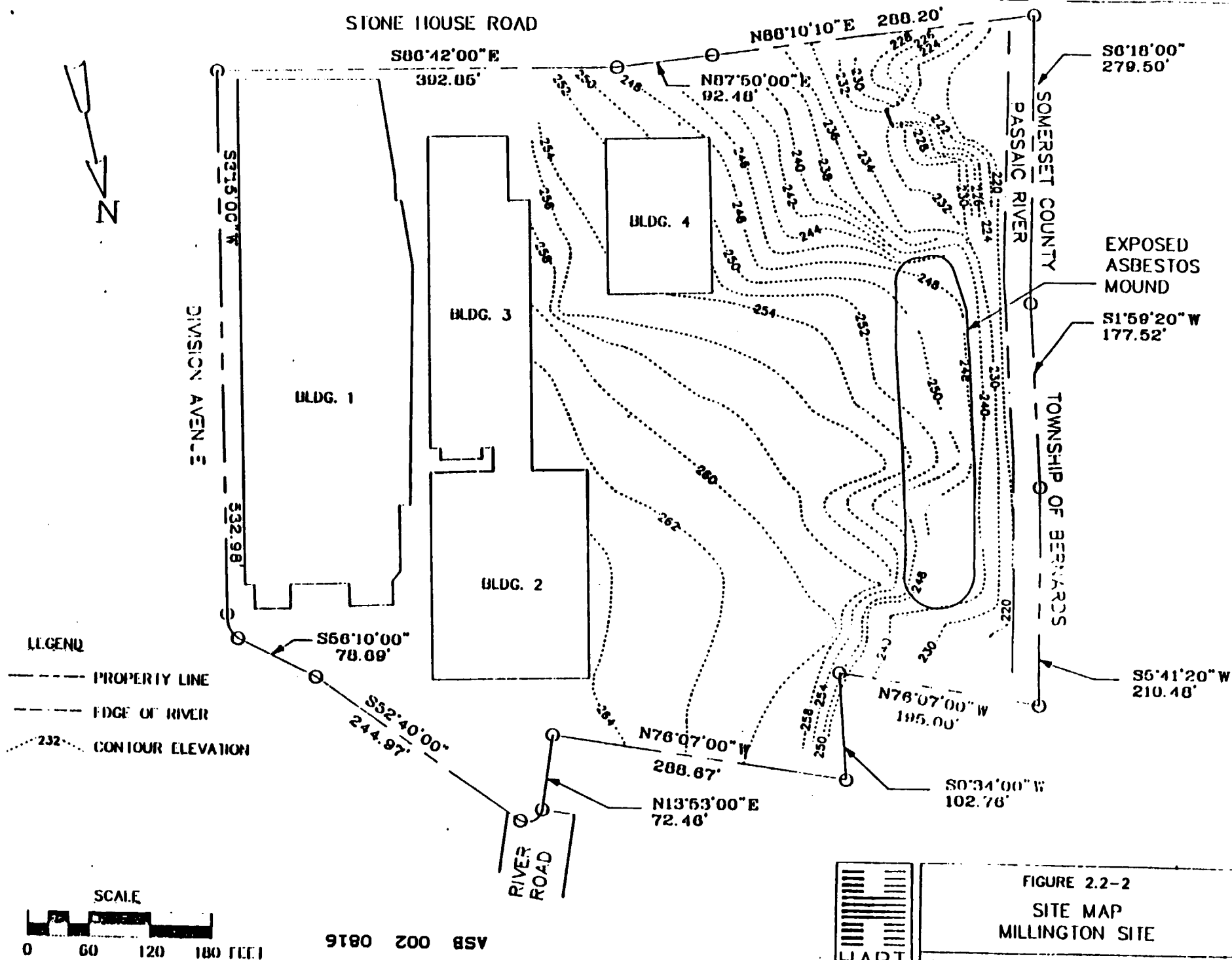
2.2 Site Description and History

The Millington Site is an 11 acre commercial property located at 50 Division Avenue in Millington, NJ. Figure 2.2-1 provides a site location map and Figure 2.2-2 provides a site map outlining the extent of the site. The site is bounded on the west by the Passaic River, on the north by the Millington Train Station, and on the east and south by commercial and private residences, respectively. Now owned by TIFA, Ltd., this site formerly housed the asbestos processing plant that was owned by National Gypsum and other previous manufacturers of asbestos products.

Manufacturing of asbestos products at the Millington Site began in 1927 by Asbestos, Ltd., which engaged in the fiberization and sale of asbestos until 1946. From 1946 until 1953, the plant was owned by Bernard E. Smith and operated under the name of Smith Asbestos, Inc., a manufacturer of asbestos roofing and siding.



ST80 200 85V



During this latter time, water from the manufacturing process was impounded on the site by dams constructed to permit settling of asbestos fibers suspended in the waste water. Periodically, sediment from the settling ponds was removed and transferred to the adjacent waste site and covered with dirt. In May 1953, the property was acquired by National Gypsum Company which manufactured cement asbestos siding and roofing sheets at the plant until 1975. During National Gypsum's period of ownership, the waste generated from the production of these materials was recaptured and recycled, with only a small amount remaining for disposal.

Waste that was not recycled consisted of broken siding and fibers. These waste products were transported off-site and used as landfilling material at the three satellite sites by independent contractors and/or individuals.

From 1959 until 1972, National Gypsum used phenylmercuric acetate (PMA) as a preservative (fungicide) in the materials used for coating the asbestos shingles. A small pit west of the plant was used for discharging material generated by the cleaning of coating equipment. From recollections of employees of National Gypsum at that time, it is estimated that 7.2 to 14.4 pounds of PMA was placed in the pit each year.

In May 1975, National Gypsum closed the Millington plant. Ownership of the land was transferred in 1978 to TIFA, Ltd., which has since divided the plant into several smaller parts that have been leased to other manufacturing and service companies.

At present, the only future planned use of the site is for a parking lot to be built within a section of the back empty field lot. This parking lot is anticipated to be used by the workers of the various business currently housed at the site.

2.3 Demography

The township of Millington contains a population of approximately 7800. Specific population at the Millington Site is approximately 200

individuals which are employed within twenty-one business throughout the site. Within the immediate vicinity of the Millington Site lie a number of points that serve as collecting centers for the local populace. North of the Millington Site lies the Millington Train Station which also houses an eatery. Approximately 300 individuals frequent the eatery during the day and about 252 individuals use the train service during peak hours. Just south of the site lies the Barrett Company which employs approximately 24 individuals.

2.4 Land Use

At present, the Millington Site is owned by TIFA Ltd. which uses some of the office space in the main building for the manufacturing of pesticide sprayers. TIFA leases the rest of the office/building space to a variety of business some of which use the parking lot between the buildings to store trailer trucks. The remainder of the site, including the open space between the buildings and the asbestos mound are not used by any site personnel.

2.5 Natural Resources

The Millington Site occupies approximately 11 acres and is located along the Passaic River. The Passaic River which lies directly west of the site boundary, flows in a north-south direction. The asbestos waste mound lies along the western sector of the site and is situated next to the Passaic River within the flood zone. Approximately ten miles downstream of the Millington Site lies the Commonwealth Water Company located in Short Hills, NJ. This institution delivers approximately 13,757,000 gallons of water per year and serves approximately 73,951 people within seven counties. The Great Swamp National Wildlife Refuge is located approximately three to five miles north of the site. The refuge covers approximately 6,833 square miles and is located within portions of Passaic and Harding Townships.

A limited number of fauna and flora exist within the Millington Site. Two distinct vegetative units were identified during field investigative

activities. The first is an old field unit located upgradient of the asbestos mound within the center of the site. This area contains short perennial grasses and annual herbaceous forbs. The other type of vegetative unit is a hardwood riparian complex along the Passaic River. Hardwood trees include Black Oak (*Quercus velatina*), Gray Birch (*Betula alleghaniensis*) and Sycamore (*Platanus occidentalis*). The understory includes Eastern Redcedar (*Juniperus virginiana*) and Common Sumac (*Rhus glabra*).

Direct or indirect observations of several wild organisms were made during field investigative activities. These include mammals [white-tailed deer (*Odocoileus virginianus*), red fox (*Vulpes vulpes*), Eastern cottontail (*Sylvilagus floridanus*), gray squirrel (*Sciurus carolinensis*), striped skunk (*Mephitis mephitis*) and opossum (*Didelphis virginiana*)]; birds [Downy woodpecker (*dendrocopos pubescens*) and black-capped chickadee (*Parus atricapillus*)]; and various reptiles and amphibians. Any commensal animals, if present, would probably include the black rat (*Rattus rattus*) and the house mouse (*Mus musculus*). Other organisms present and not observed, but expected would be various rodent species of the family Cricetidae. Various species of finfish would be expected in the Passaic River.

2.6 Climatology

The Millington Site is located within the Passaic River Basin. Climate for this area is typical of the entire Middle Atlantic seaboard. Winters and summers are moderate. The average annual temperature is approximately 54°F. The mean annual relative humidity varies from 67% to 73%. Prevailing winds are from the northwest with an average velocity of 9.7 miles per hour.

Average precipitation is approximately 47.3 inches with the distribution of precipitation throughout the year fairly uniform. The 24 hour maximum rainfall per year estimate is approximately 2.8 inches. This value has been determined over a two year period.

Data for evaporation during peak evaporation periods (March-November) indicates a high value of 6.99 inches for June and a low of 0.32 inches for October. The average evaporation over this time interval is estimated at 4.0 inches.

ASB 002 0820

3.0 SUMMARY OF FIELD INVESTIGATIVE ACTIVITIES

3.1 Introduction

Field activities at the Millington Site occurred from August 1986 through November 1987. Field activities were designed and incorporated to determine the nature and extent of disposed materials and to obtain detailed information on geologic and hydrogeologic conditions. The bulk of the field work consisted of the drilling, installation and sampling of seven monitoring wells. In addition, a comprehensive environmental sampling effort was instituted and consisted of sampling air, surface water, sediments, groundwater, and biota at and in the vicinity of the site. An engineering investigation was designed specifically for geotechnical analysis of the asbestos mound located along the western sector of the Millington Site.

This chapter contains a discussion of the purpose, procedures and results of each field activity and presents the data generated by these activities.

3.2 Test Borings Operations

3.2.1 Purpose. A total of seven test borings were drilled at the Millington Site by Empire Soils Investigation, Inc. of Highland Park, NJ. All test borings were constructed at strategically selected locations within each site to characterize contaminant disposal, subsurface geology and hydrogeology.

3.2.2 Methodology. Seven test borings, all of which were converted to monitoring wells, were drilled at the Millington Site (Table 3.2-1). The test borings were constructed at the site in the following geographic locations (Figure 3.2-1): three test borings (TB-902-904) were constructed on the asbestos hill which is located

TABLE 3.2-1
CONSTRUCTION DETAILS OF TEST BORINGS
MILLINGTON SITE

<u>Test Boring Number</u>	<u>Total Depth Drilled (ft)</u>	<u>Depth To Water (ft)</u>	<u>Total Number Soil Samples</u>	<u>Monitor Well Installation</u>
901	50.0	30.0	2	Open Bedrock Well
902	33.0	28.0	7	Yes
903	36.0	28.5	18	Yes
904	33.5	28.4	8	Yes
905	6.0	4.0	3	Yes
906	16.0	15.5	9	Yes
907	10.0	9.5	4	Yes

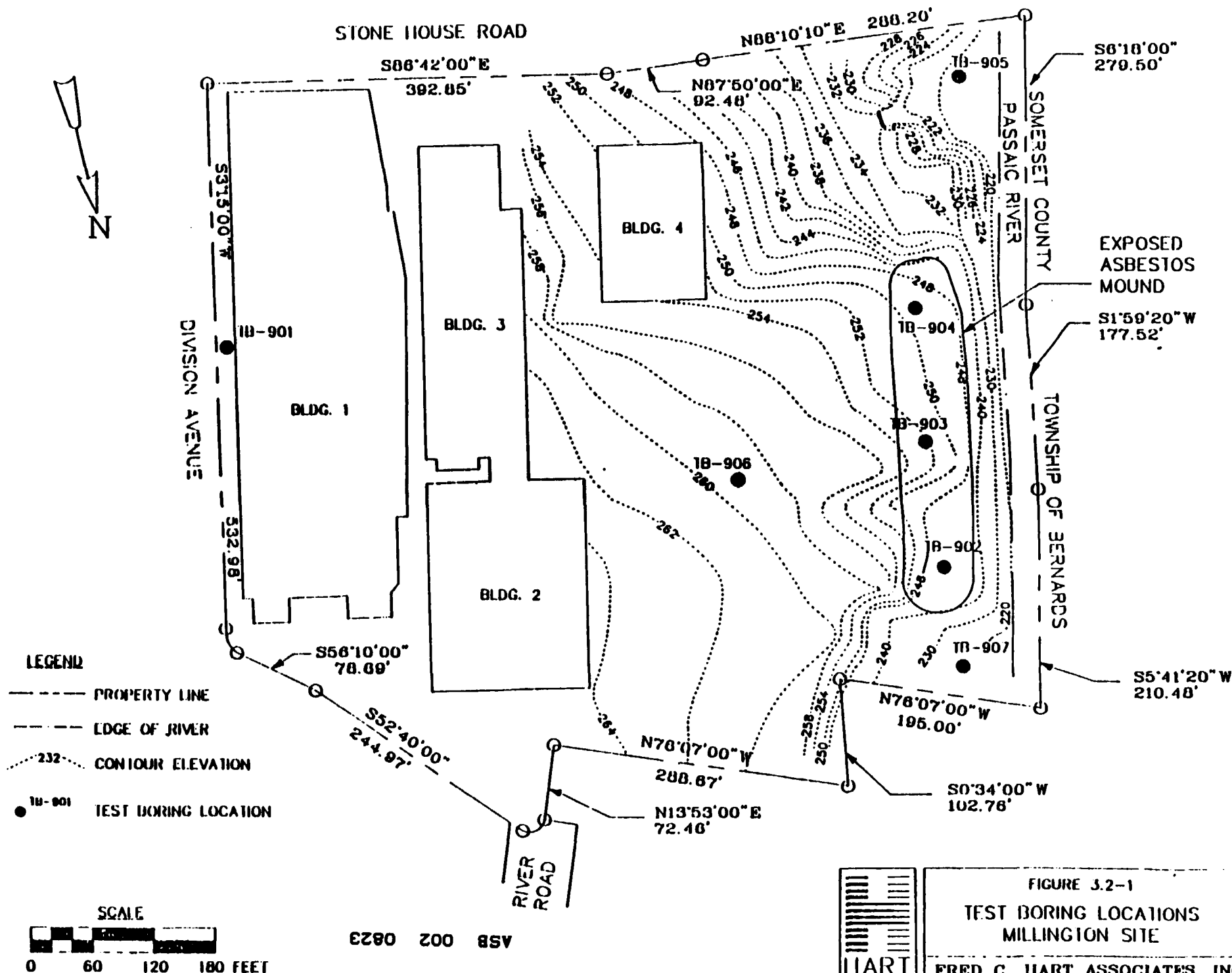


FIGURE 3.2-1
TEST BORING LOCATIONS
MILLINGTON SITE
FRED C. HART ASSOCIATES, INC.



along the Passaic River; two (TB-905 and 907) were drilled below the flanks of the asbestos hill; one (TB-906) was constructed in the vicinity of a former phenylmercuric acetate disposal pit; and one (TB-901) at an upgradient location near Division Avenue.

3.2.2.1 Test Borings. Test borings and monitoring wells were installed by Empire Soils Investigations, Inc. of Highland Park, NJ. Test boring operations commenced at the Millington Site at the beginning of August 1986.

All test borings were drilled to a shallow depth within unconsolidated deposits overlying bedrock. At the Millington Site, drilling involved the use of a mobile B-61 drill rig with hollow-stem augers.

The test borings were drilled using five-foot flight hollow-stem augers of 6 3/4 inch inner-diameter (I.D.). The borings were advanced within the consolidated zone until the desired depth below the water table for monitoring well screen placement was reached.

All drilling equipment used (i.e., drill bits, augers, rods, rig) was decontaminated between test borings to eliminate the possibility of cross-contamination. The decontamination process consisted of the removal of bulk solids for all apparatus with a hot water, high pressure wash.

All formation cuttings and decontamination fluids were drummed separately. These materials are awaiting disposal following laboratory analysis of the drummed material and containerized wastewater.

3.2.2.2 Soil Sample Collection and Analysis. Lithologic samples were collected either, continuously, at 2.5, or 5.0 foot intervals in advance of the boring. Undisturbed samples were collected with a two-inch diameter, two foot long split spoon sampler driven over a two foot interval with a 140 pound hammer falling 30 inches. The split spoon

samplers used at each boring were decontaminated prior to sampling and between sampling using the following procedures:

- Scrubbed clean in soapy water with a scrub brush
- Tap water rinse
- Deionized water rinse
- Methanol rinse
- Hexane rinse
- Deionized water rinse

All sampling equipment (split spoons, knives, etc) was pre-cleaned, using the procedure described above, at York Laboratories and wrapped in heavy aluminum foil for transport into the field. All samples were collected and described in detail by a HART field geologist during boring operations. Descriptions included:

- a. soil characteristics (type, thickness, color, etc.)
- b. waste characteristics (odor, texture, material, etc.)
- c. visual contamination description
- d. approximate water content

Samples were obtained from each split spoon with a clean knife and placed either into eight ounce jars and stored in archives or were placed into one six ounce jar and two VOA vials, laboratory prepared according to EPA procedures, and sent to a laboratory for chemical analysis.

At the request of EPA, a random soil sampling program was implemented at the Millington Site. The fifteen randomly selected soil samples were chosen via a random numbers chart. After estimating the approximate number of total soil samples to be collected, a representative number of these samples were selected for analysis. It was this number to be laboratory-analyzed that was selected with the random numbers chart. For example, at the Millington Site, it was estimated that a total of 82 split

spoon samples would be recovered from the site and that 15 of these samples were to be selected for laboratory analysis. Fifteen numbers ranging between 1-82 were then drawn from the random numbers chart and the corresponding split spoon samples, retrieved in the field, were sent to the laboratory.

3.2.3 Findings.

3.2.3.1 Subsurface Characteristics. Test boring logs prepared by HART are in Appendix A. The data obtained from the test borings was used to construct cross-sections and prepare the description of site geology provided in Section 4.2.2.

3.2.3.2 Analytical Results. In an effort to assess the nature and extent of contamination present at the Millington Site, 15 randomly selected soil samples (Table 3.2-2) underwent Priority Pollutant plus forty analysis. Laboratory analysis was conducted by York Laboratories (YHC) of Monroe, Connecticut. Tables 3.2-3 and 3.2-4 contain a summary of the analytical data. Only detected parameters have been included in the tables. Laboratory Data Sheets, case narratives, and a QA/QC review of the test boring data are contained in Appendix B.

Analytical results for the fifteen on-site test boring samples and one duplicate are shown in Tables 3.2-3 and 3.2-4. Table 3.2-3 contains a summary of the inorganic data and organic data is summarized in Table 3.2-4. Metals concentrations were compared to the table of average content of the trace elements in soils prepared by EPA (Hazardous Waste Land Treatment, SW-874, April 1983) (Table 3.2-5). A total of seven metals ranging in concentration from 0.14 to 309 mg/kg were detected in the samples from the five test borings. Mercury was present in thirteen of the test boring samples. Ten of the soil samples had concentrations of mercury ranging from 0.39 to 7.8 mg/kg which are levels above the common range of mercury in natural soils. The other three soil samples had concentrations of mercury that ranged between 0.14 and 0.24 mg/kg which are concentrations within standard levels for this element in soils.

ASB 002 0826

TABLE 3.2-2
LABORATORY ANALYZED TEST BORING SAMPLES

<u>Site</u>	<u>Test Boring</u>	<u>Sample Numbers</u>
Millington Site	902	29, 31, 35
	903	9, 12, 13, 16
	905	50
	906	36, 37, 38 (Du- plicate of 37), 39, 42, 43
	907	44, 46

TABLE 3.2-3
SUMMARY OF INORGANIC DATA
MILLINGTON SITE
TEST BORING SAMPLES

	Sample Number															
	TB-903				TB-902			TB-906				TB-907		TB-905	Field Blank	
elals (mg/kg)	9	12	13	16	29	31	35	36	37**	39	42	43	44	46	50	8/27/86
Arsenic	--	--	--	--	--	--	6.04	7.37	--	--	--	--	--	2.30	--	--
Chromium	59.3	42.1	64.3	24.8	58.8R	46.1R	26.5R	30.6R	47.9R	83.3R	34.7R	26.3R	25.4R	26.6R	29.2	--
Copper	49.4	--	22.6	12.5	31.9*	15.4	41.9*	37.3*	25.7*	68.2*	16.6*	17.0*	59.0*	16.7*	18.9	--
Lead	39.4R*	11.2R*	18.8R*	19.1R*	7.62*	9.07*	16.6*	79.7*	8.12*	27.2*	6.24*	14.1*	88.1*	16.0*	21.3*R	--
Mercury	1.79	--	6.6R	0.14	0.83	0.39	--	0.16	1.18	7.8	0.42	2.4	1.66	0.24	0.42	--
Nickel	147*	109	160	13.4	301R	179R	40.3R	51.5R	113R	55.2R	104R	57.6R	35.6R	18.5R	23.7	--
Zinc	57.9*	27*	38*	38.5*	77.5	17.5	75.1	82.7	29.3	309	21.7	50.1	82.1	55.4	64.6*	--
vanide (mg/kg)	0.10	0.10	--	--	--	--	--	--	--	--	--	--	--	0.17	0.13	--

Indicates duplicate analysis is not within control limits.

Indicates spike sample recovery is not within control limits.

- Indicates compound was analyzed for but not detected.

* Sample 37 is a duplicate of sample 38. Not enough of Sample 38 was provided to the laboratory for analysis.

Blank space indicates that the sample was not analyzed for that parameter.

U Test Boring

TABLE 3.2-4

SUMMARY OF ORGANIC DATA
MILLINGTON SITE
TEST BORING SAMPLES

	10-903				10-902			10-906					Trip Blank 8/13/86	10-907		Trip Blank 8/14/86	10-905	Field Blank 8/27/86
Volatile Organics (ug/kg)	9	12	13	16	29	31	35	36	37**	39	42	43		44	46		50	
Methylene Chloride	800	208	1108	338	--	848	358	178	208	1508	518	538	238	118	938	438	438	1808
Trichlorofluoromethane	438	438	338	0.438	103	13	--	.53	--	93	23	--	--	.43	.33	--	--	--
Acrylonitrile	--	--	--	--	93	--	--	--	--	--	--	--	--	--	--	--	--	--
1,1-dichloroethene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	13	--
Chloroform	118	168	838	338	--	113	33	43	5.03	218	118	118	--	68	438	238	438	68
1,1,1-trichloroethane	--	--	--	--	--	--	--	.93	--	--	33	23	--	--	--	--	--	--
Trichloroethene	--	--	93	--	80	83	--	23	--	83	63	53	--	--	--	--	138	--
Benzene	338	638	338	238	20	33	.853	.73	53	338	538	238	--	--	--	--	13	--
Toluene	258	223	--	538	418	888	148	138	938	33	30	54	23	--	--	--	--	23
Ethyl Benzene	--	--	--	--	--	--	--	13	--	--	--	43	--	--	--	--	--	--
Base-Neutral Extractables (ug/kg)																		
Naphthalene	--	--	--	--	--	--	--	4038	--	--	--	--		638	438		438	0.138
Acenaphthylene	--	--	--	--	--	--	--	73	--	--	--	--		--	--		--	--
Acenaphthene	--	--	--	--	--	--	--	1403	--	--	--	--		--	--		--	--
Diethyl phthalate	--	--	--	--	--	--	--	838	--	--	--	--		103	--		173	0.638
Fluorene	--	--	--	--	--	--	--	1203	--	--	--	--		--	--		--	--
Phenanthrene	--	--	--	--	--	--	--	1200	--	--	--	--		813	--		--	--
Anthracene	--	--	--	--	--	--	--	2603	--	--	--	--		203	--		--	--
Di-n-butyl phthalate	--	--	--	--	--	--	--	833	--	--	--	--		4438	4138		2938	--
Fluoranthene	--	--	--	--	--	--	--	1800	--	--	--	--		1803	--		--	--
Pyrene	--	--	--	--	--	--	--	1700	--	--	--	--		93	--		--	--
Chrysene	--	--	--	--	--	--	--	880	--	--	--	--		--	--		--	--
Benzo(a)anthracene	--	--	--	--	--	--	--	720	--	--	--	--		923	--		--	--
Bis-2-ethylhexyl phthalate	--	--	--	--	--	--	--	--	--	--	--	--		6208	23038		16238	0.938
Di-n-octyl phthalate	--	--	--	--	--	--	--	--	--	--	--	--		--	--		--	53
Benzo(b)fluoranthene	--	--	--	--	--	--	--	780	--	--	--	--		--	--		--	--
Benzo(k)fluoranthene	--	--	--	--	--	--	--	150	--	--	--	--		--	--		--	--
Benzo(a)pyrene	--	--	--	--	--	--	--	730	--	--	--	--		873	703		263	--
Benzo(g,h,i)perylene	--	--	--	--	--	--	--	570	--	--	--	--		--	--		--	--
Dibenzo(a,h)anthracene	--	--	--	--	--	--	--	473	--	--	--	--		--	--		--	--
Indeno(1,2,3,cd)pyrene	--	--	--	--	--	--	--	480	--	--	--	--		523	--		--	--
4-chloro-3-methyl phenol	--	--	--	--	--	--	--	203	--	--	--	--		--	--		--	--
4-nitrophenol	--	--	--	--	--	--	--	--	--	--	--	--		343	--		--	--
Heruls (mg/kg)	--	5.3	--	--	--	--	--	--	--	--	--	--		--	5.74		--	8
Pesticides-PCBs (ug/kg)																		
4,4'-DDE	--	--	--	--	--	--	5.23	--	--	--	A	--	--	--	--	--	--	--

- Indicates compound was analyzed for but not detected.

Indicates that the concentration listed is an estimated value which is less than the specified minimum lower detection limit but is greater than zero.

Sample polymerized during extraction.

Analyte was found in the method blank as well as in the sample.

* Sample 37 is a duplicate of sample 38. Not enough of Sample 38 was provided to the laboratory for analysis.

Blank space indicates that sample was not analyzed for that parameter.

B Test Boring

TABLE 3.2-5
TRACE ELEMENT CONTENT OF NATURAL SOILS

<u>Element</u>	<u>Common Range (mg/kg)</u>	<u>Average Range (mg/kg)</u>
Antimony	2-10	-
Arsenic	1-50	5
Beryllium	0.1-40	6
Cadmium	0.01-0.7	0.06
Chromium	1-1000	100
Copper	2-100	30
Lead	2-200	10
Mercury	0.01-0.3	0.3
Nickel	5-500	40
Selenium	0.1-2	0.3
Silver	0.01-5	0.05
Zinc	10-300	50

Reference: USEPA Office of Solid Waste and Emergency Response, HAZARDOUS WASTE LAND TREATMENT, SW-874 (April, 1983) Page 273, Table 6.46.

Arsenic, the metal least abundant, was detected in only three test boring samples. Concentrations of this metal ranged from 2.30 mg/kg - 7.37 mg/kg which is within the the standard range of the element in natural soils.

The remaining metals and their range of detected concentrations include chromium (24.8-83.3 mg/kg); copper (12.5-68.2 mg/kg); lead (6.24-88.1 mg/kg); nickel (13.4-301 mg/kg) and zinc (17.5-309 mg/kg). These metals were detected in almost every sample analyzed and their concentrations are within acceptable limits when compared to the table of average content of the trace elements in soils (Table 3.2-5). Sample 39 contained 309 mg/kg of zinc which is slightly above the upper range limit of this element in natural soils.

It should be noted that the test boring samples consisted of three different types of material from four units (silty-clay topsoil fill, asbestos waste mound, subsurface asbestos waste and the underlying silt/clay unit) and that neither material was more contaminated than the other. Samples 36 and 37 were collected from the topsoil fill; Samples 9, 12, 13, 29, 31 were taken from the asbestos waste pile; Samples 39, 42, and 43 from the subsurface deposits of asbestos; and Samples 16, 35, 44, 46 and 50 from the lower silt/clay unit. The metals are, for the most part, equally concentrated in number and concentrations within all four units.

The highest concentrations of chromium, copper, mercury, nickel and zinc are from test boring samples recovered from the asbestos fill deposits. Samples recovered from the lower unit of silt/clay contained higher concentrations of lead only. Arsenic was found in most abundance in the silty/clay topsoil fill deposit that overlies the asbestos waste materials at TB-906.

Ten volatile organic compounds were detected in the test boring samples (Table 3.2-4) at concentrations ranging from 0.3-150 ug/kg. These compounds were mostly present in soil samples from the asbestos hill. Methylene chloride, a common laboratory contaminant, was detected in all

samples including method and trip blank samples at the largest detected concentrations, 4-150 ug/kg. Trichlorofluoromethane (0.3-10 ug/kg), chloroform (3-21 ug/kg), and toluene (5-88 ug/kg) were the only compounds present within the asbestos waste products, lower silt/clay unit, and within the top soil fill deposits. Since all four compounds were also detected in method blank samples and were present in a trip blank (except trichlorofluoromethane), their presence may not be indicative of soil contamination.

Of the remaining detected volatiles, an estimated value of acrylonitrile (9 ug/kg) was indicated in only one soil sample from the asbestos hill. Ethyl benzene (1-4 ug/kg), trichloroethene (1-80 ug/kg), and 1,1,1-trichloroethane (0.9-3 ug/kg) were detected in the asbestos waste and topsoil fill deposits. Benzene was limited in distribution to the asbestos waste material (2-20 ug/kg) and lower silt/clay unit (0.85-2.0 ug/kg) but was also present in a method blank.

The detected base neutral extractable compounds (Table 3.2-4) were restricted to one test boring sample (36) from the topsoil fill deposit and three test boring samples (44, 46, 50) from the lower silt/clay unit. None of these compounds were detected in the asbestos mound and other areas containing asbestos waste. A total of twenty-one such compounds were identified ranging in concentration from 4-1800 ug/kg. Sample 36, recovered from the topsoil fill deposit, contained 19 detected base neutral compounds, sixteen of which were polynuclear aromatic hydrocarbons (PAHs). PAHs are common coal tar constituents. Concentrations of PAHs in this sample ranged from a low of 7 ug/kg (acenaphthylene) to a high of 1,800 ug/kg (fluoranthene).

Twelve base neutral compounds were detected in the test boring samples from the lower silt/clay unit at concentrations ranging from 4-620 ug/kg. With the exception of bis-2-ethylhexyl phthalate in sample 44, the concentrations of these compounds are estimated and below the detection limits. Sample 44 contained the most detected compounds (12), and sample 46 the least (4). Naphthalene (4-6 ug/kg); di-n-butyl phthalate (29-44 ug/kg); bis-2-ethylhexyl phthalate (162-620 ug/kg); and benzo(a)py-

rene (26-87 ug/kg) were detected in all the samples recovered from this unit. The first three compounds were also detected in the method blank. Seven base neutral compounds were restricted in distribution to sample 44 recovered in the silty/clay unit beneath the former disposal pit area (TB-906). With the exception of 4-nitrophenol, these compounds are all classified as PAHs.

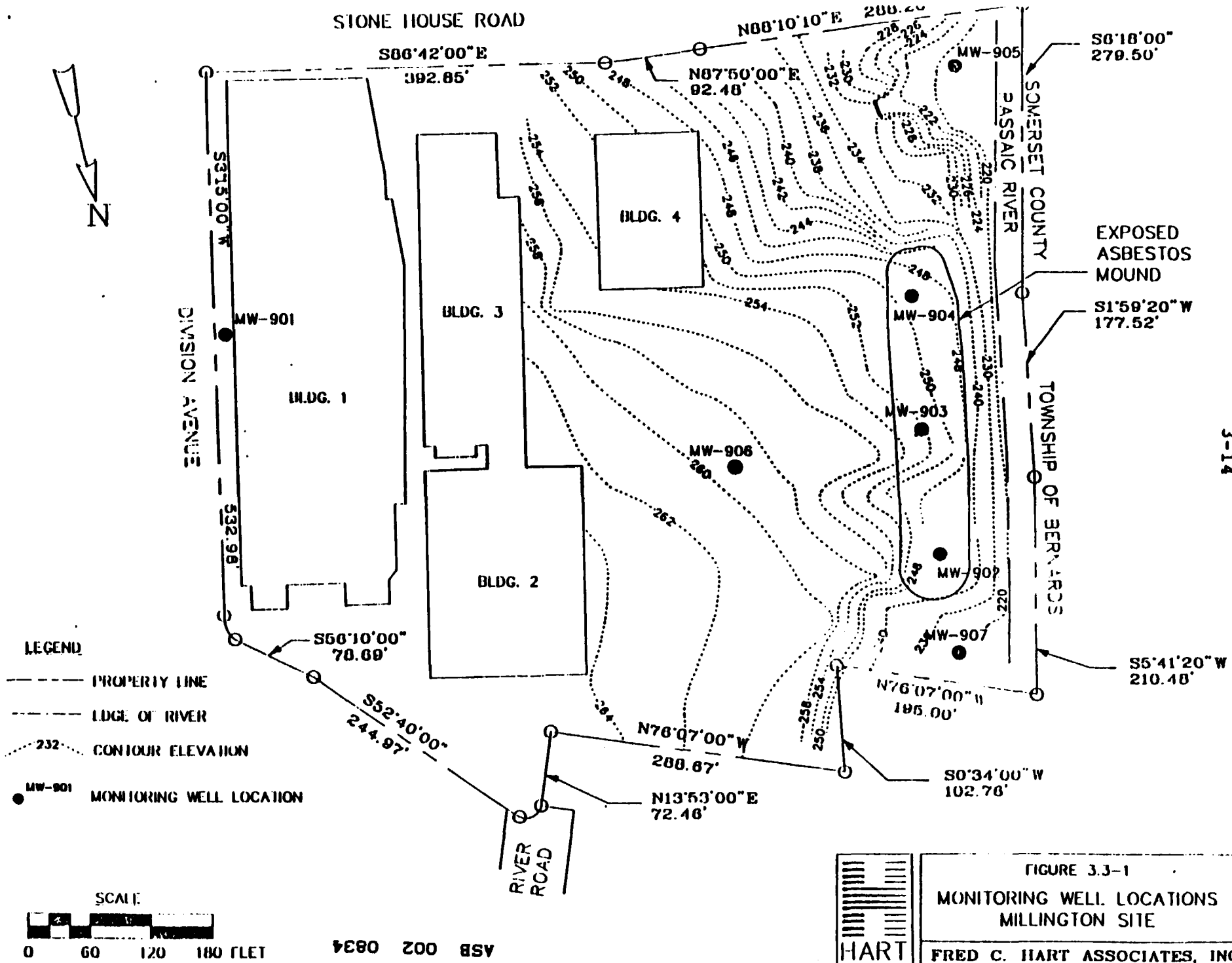
Other compounds identified at this site include cyanide (0.10-0.17 - mg/kg) which was detected in two test boring samples (9 and 12) from the asbestos hill and two samples (46, 50) recovered from the lower silt/clay unit at TB-907 and TB-905, respectively. Phenols were present in two test boring samples (12 and 46) at levels ranging from 5.3-5.7 mg/kg. One pesticide constituent, 4,4-DDE, was identified from sample 31 located within the asbestos hill at TB-902, at an estimated concentration of 5.2 ug/kg.

3.3 Monitor Well Installation

3.3.1 Purpose. A total of seven groundwater monitoring wells were installed at the Millington Site (Figure 3.3-1). These wells were installed to obtain the necessary hydrological and chemical data needed to determine the groundwater flow direction and potential contaminant migration in these areas.

3.3.2 Methodology.

3.3.2.1 Unconsolidated Monitor Wells. Six of the seven monitoring wells were constructed in accordance with "New Jersey Department of Environmental Protection Unconsolidated Monitor Well Specifications." These wells were constructed of four-inch diameter, 316 stainless steel (threaded flush joint) and five or ten-foot long 20-slotted stainless steel screen.



The monitor wells were installed immediately following the completion of selected test borings. The procedure followed for well installation was basically the same in each borehole. After drilling down to the desired depth of well placement, the hole was filled with one or two inches of gravel. This provided a base on which to set the screen. The well was then set into the borehole through the hollow-stem augers and held in place while the annular space around the screen was backfilled with gravel pack up to one and one-half feet above the top of the screened interval. A bentonite seal of one-half to 2 feet was emplaced above the gravel pack, and the remainder of the borehole was tremmie-grouted with a cement/bentonite slurry. The augers were retracted from the borehole as the well was constructed. A five foot long protective steel casing was then set into the borehole and grouted in place with cement. A cement pad was also constructed around the protective casing to prevent any surface water from draining directly into the well. All monitoring wells had locking caps and locks, along with well permit numbers affixed to them.

Following installation, all wells were developed by pumping with a trash pump. The purpose of well development is to create good hydraulic connection between the well and the aquifer by removing formational fines. Water was pumped from the well until visibly free of sediment.

One adjustment was made to well construction parameters that were originally proposed in the Site Operations Plan. This adjustment is listed below:

- Screens could not be set 10 feet below the water table at the Millington Site. This is a result of the water table directly overlying bedrock in this area. Instead, the screen was set at the top of the bedrock zone and penetrated the total water table.

This adjustment was approved by EPA prior to its implementation.

3.3.2.2 Rock Monitoring Well. One rock monitoring well was constructed in accordance with "New Jersey Department of Environmental Protection Rock Monitor Well Specifications." This well (MW-901) was constructed at the Millington Site as a background well.

This well was constructed in two phases of operation. The first phase involved boring down to bedrock as described in Section 3.2.2.1. Following the completion of the initial test boring, the second phase of operation involved drilling with an air-rotary drill rig which was used to complete the borehole. The boring was advanced into bedrock with an eight inch drill bit. Drilling proceeded to 13 feet below grade into a zone of competent bedrock. Following this initial bedrock drilling, the borehole was then cased with six-inch galvanized steel casing and grouted in place to prevent cross-contamination between the upper, unconsolidated zone and underlying bedrock. Drilling then continued inside the casing to a depth of 50 feet below grade.

After the drilling was complete, the well was also provided with a cement pad, locking cap and well permit number. In addition, this well was developed with a trash pump as described in Section 3.3.2.1.

3.3.3 Findings. The monitoring well construction diagrams are contained Appendix C.

3.4 Casing Elevation Survey and Water Level Measurements

3.4.1 Purpose. Following completion of the monitoring well installation, the mean sea level (MSL) of the stainless steel riser pipes and the well locations were surveyed by Azzolina & Feury Engineering Company of Paramus, N.J. This data, in conjunction with water level measurements collected by HART personnel, enabled HART personnel to contour the potentiometric surface and determine groundwater flow directions.

3.4.2 Methodology.

3.4.2.1 Well Elevation Survey. Elevations of inner stainless steel casings were determined utilizing differential leveling techniques. The elevations were surveyed relative to mean sea level. To insure consistency of measurements, readings were taken on the northern side of the inner well casings, and the location noted on the casing.

3.4.2.2 Water Level Measurements. HART personnel obtained water level measurements of all wells on November 29, 1986. The instrument probe (Slope Indicator Co. Model S1453) was lowered from the top of the stainless steel riser down the well. When the electrode came into contact with the water, an audio signal was emitted from the instrument. Potentiometric maps were then constructed from the water level measurements.

3.4.3 Findings. Results of the survey and groundwater level measurements can be found in Table 3.4-1.

3.5 Engineering Analysis

3.5.1 Purpose. An engineering investigation program was conducted on the asbestos mound at the Millington Site in conjunction with the hydrogeologic investigation. The purpose of the engineering program was to produce the following data pertaining to the asbestos mound: stability and structure; details of spoil and in-situ materials; and the feasibility of slope revegetation.

3.5.2 Engineering/Physical Properties

3.5.2.1 Purpose. The laboratory testing program was conducted to evaluate the engineering and physical properties of the undisturbed soil and spoil materials at the Millington Site. Inspection and evaluation of the samples indicated that seven (7) relatively undisturbed samples were suitable for testing. Six of the samples were obtained in the spoil material (asbestos) and one sample was obtained from the in-situ soil.

ASB
002
0837

TABLE 3.4-1
CASING ELEVATIONS AND WATER LEVEL MEASUREMENTS

<u>Site</u>	<u>Well No.</u>	<u>Elevation of North Rim (MSL)</u>	<u>11-29-86 Elevation of Ground Level at Well (MSL)</u>	<u>11-29-86 Depth to Water From Stainless Steel Riser (Ft.)</u>	<u>Ground water Elevation (MSL)</u>
Millington Site	901	272.82	270.59	29.30	243.52
	902	250.26	247.82	21.15	229.11
	903	252.28	250.24	24.10	228.18
	904	249.40	247.26	24.42	224.98
	905	221.44	219.52	2.45	218.99
	906	262.34	259.45	16.02	246.32
	907	225.66	223.43	6.48	219.18

MSL - Mean Sea Level

ASB 002 0838

The testing program included determination of natural moisture content, Atterberg limits and dry unit weights, as well as a consolidation test and a triaxial strength test.

3.5.2.2 Methodology. Material used in the analyses of engineering and physical properties were obtained from Shelby tube samples. Thirteen Shelby tube samples were obtained from TB-902 and TB-904 during the hydrogeologic investigation (Appendix A). Shelby tube sampling consisted of attaching a 24-inch Shelby tube to a drill rod (on the drilling rig) and advancing the Shelby tube ahead of the augers through the appropriate sampling intervals. The sample was immediately prepared for shipment by covering it with parafin at each end of the tube to preserve the natural moisture content. A summary of the various tests performed as part of the laboratory investigation is presented below:

Natural Moisture Content: The moisture content, or the ratio of the weight of water to the dry weight of solids within a sample, was determined for all undisturbed samples. Moisture content is an index property used in the calculation of soil weight-volume relationships which is utilized in many engineering analyses and for the classification and grouping of materials.

Atterberg Limits: The liquid and plastic limits were determined for two of the asbestos samples and one sample of in-situ material. Atterberg limits are used in the classification and identification of soils and in empirical correlations with engineering properties, such as strength and deformability.

Dry Unit Weight: The dry unit weights of all undisturbed Shelby tube samples were obtained in the laboratory. The dry unit weight is defined as the ratio of the weight of the solids within the sample to the volume of the total sample, and is usually expressed in pounds per cubic foot (pcf). Unit weights are used extensively in engineering calculations such as slope stability analysis and settlement determinations.

Consolidation test: One consolidation test was performed on the sample of in-situ material. The consolidation test was performed to obtain several indices which characterize the time-dependent settlement of the soil due to the dissipation of porewater within the soil. Typically, the test is used to evaluate the compression and recompression indices, the preconsolidation stress, and the coefficient of consolidation, which are all used in settlement analyses.

Triaxial Strength Test: The most commonly used laboratory shear test for determination of strength characteristics of cohesive soils is the triaxial test. This test permits the evaluation of soil strength in terms of cohesion (typically referred to as "C") and angle of internal friction (typically referred to as "φ", in degrees) under a variety of loading conditions. Depending on the test procedure, either total or effective stress parameters can be determined; total stress parameters represent the strength provided by both the soil structure and porewater pressure, whereas effective stress parameters represent strength provided by the soil structure only.

There are three conditions under which triaxial tests are routinely performed:

1. Unconsolidated Undrained (UU) - Both confining and shear stresses are applied to the sample without allowing for pore pressure reduction through drainage, such that the stresses are carried by soil and pore fluid. This procedure will measure total stress parameters only and is representative of rapid loading conditions.
2. Consolidated Undrained (CU) - Confining stresses are applied and the sample is allowed to consolidate at predetermined stress levels to simulate anticipated field conditions. Drainage is then stopped, and the sample tested under undrained conditions. For these conditions, the initial confining stress is supported by the soil structure only, with pore pressure being zero. As

ASB 002 0840

the load is applied, pore pressure increases and the total strength at predetermined stress levels is measured. If pore-water pressures are monitored, this test procedure can be used to determine both total and effective stress parameters.

3. Consolidated Drained (CD) - Both confining and shear stresses are applied slowly to allow any resultant porewater pressure to totally dissipate from the sample. Consolidation and concurrent shear strength increase will occur due to the applied stress. This procedure will measure effective stress parameters only, as no porewater pressure will be present within the loaded sample.

Each of these three procedures corresponds with a general construction condition. For UU conditions, it is assumed that construction occurs so rapidly that excess porewater pressure cannot dissipate, as often occurs in footing or foundation construction. For CU conditions it can be assumed that loading occurs in increments such that the soil can develop additional shear strength from each load increment (due to soil consolidation) before the next load increment is added. Finally, CD conditions occur if loading is slow enough to allow all porewater pressure to dissipate, such as in long-term stability of excavations.

In the case of the asbestos pile at the Millington Site, it is assumed that the asbestos has consolidated over time and additional stresses will be applied quickly with no drainage occurring. Thus the consolidated - undrained (CU) triaxial test was conducted using six of the undisturbed asbestos samples to obtain representative strength data to be used in the stability analysis. In the original work plan, two additional laboratory tests, particle size analyses and specific gravity, were to be conducted on the asbestos. However, these tests could not be successfully completed due to the fibrous nature of the asbestos.

3.5.2.3 Findings. The results of the laboratory testing program, indicate that the asbestos is significantly different from a typical soil. The moisture content of the asbestos samples were high, ranging from 117% to 512%. The moisture content of the in-situ soil was 24.4%.

The unit weights of the asbestos were low, with values between 13.4 pcf and 38.1 pcf, whereas the unit weight of the native soil was 102.4 pcf. In addition, the asbestos had relatively low strength values. The cohesion intercept was determined to be 150 pcf and a friction angle of 15°. The asbestos samples were non-plastic.

The results of all the laboratory tests are included in Tables 3.5-1 - 3.5-3.

3.5.3 Stability Analysis

3.5.3.1 Purpose. The following analysis was conducted to evaluate the slope stability of the asbestos pile at the Millington Site. It has been observed from site visits that the existing slopes of the asbestos pile may be at risk of possible landslides. Existing slopes in some areas are steep, approximately one and one-half (1.5) horizontal to one (1) vertical, and along the southeastern limit of the pile these slopes terminate at the edge of the Passaic River. Hence, it was decided to further investigate the existing site slope by conducting rigorous slope stability analysis using state-of-the-art computer techniques available.

3.5.3.2 Methodology. Stability analysis for the asbestos pile at the Millington Site was performed by applying the modified Bishop method of slices. The STABL3 computer program, developed at Purdue University, was used for this analysis. STABL3 is a computer program written in FORTRAN IV source language for the general solution of slope stability problems by a two dimensional limiting equilibrium method. Limit equilibrium analysis is used in design to determine the magnitude of the factor of safety. Regardless of the specific procedure for carrying out the computations, the following principles are common to all methods of limit equilibrium analysis:

ASB 002 0842

3-23

TABLE 3.5-1

SUMMARY OF LABORATORY TEST RESULTS

HILLINGTON SITE

Boring and Sample No.	Depth (Feet)	Description	Natural Water Content (%)	Atterberg Limits		Dry Unit Weight (pcf)	Consolidated-Undrained Triaxial Test	Consolidation Test
				Liquid Limit (%)	Plastic Limit (%)			
B902 S3	2.5-4.5	Asbestos	321	NP	NP	16.3		
B902 S4	20.5-22.5	Asbestos	512	NP	NP	13.4		
B904 S1	4.5-6.5	Asbestos	338 285			14.5 17.6		
B904 S2	6.5-8.5	Asbestos	134 117			35.1 38.1	C=150 psf 0-15°	
B904 S3	11.0-13.0	Asbestos	336			16.1	Note: See test curve	
B904 S4	16.0-18.0	Asbestos	228			23.0		
B902 S7	29.5-31.5	Brown Silty Clay	24.4			102.4		See test curve

NP - Non-Plastic

Pcf - Pounds Per Cubic Foot

ASB 002 BSV

(0285P:4)

021288

TABLE 3.5-2

TRIAXIAL COMPRESSION TEST REPORT OF ASBESTOS MOUND
MILLINGTON SITE

CURVE NO.	SAMPLE NO.	ELEV. OR DEPTH	CLASSIFICATION	WATER CONTENT (%)		ATTERBERG LIMITS		SPECIFIC GRAVITY	DRY DENSITY (PCF)		STRESS (PSF)	STRAIN (%)	CELL PRESSURE (PSF)	C (PSF)	ϕ DEGREES	\bar{C} (PSF)	$\bar{\phi}$ DEGREES
				BEFORE	AFTER	LIQUID LIMIT	PLASTIC LIMIT		BEFORE	AFTER							
1	904 ₂₁	4 1/2 - 6 1/2	Asbestos		338	—	—			14.5							
2	904 ₂₄	7 1/2 - 10	Asbestos		223	—	—			23.0							
3	904 ₂₁	4 1/2 - 6 1/2	Asbestos		285	—	—			17.6			150	15°	—	—	
4	904 ₂₆	6 1/2 - 8 1/2	Asbestos		134	—	—			35.1							
5	904 ₂₆	6 1/2 - 8 1/2	Asbestos		117	—	—			32.1							

Using Tubes 1 & 2 only (Same Depth)
Discount Tube 4 - (Deep Sample)

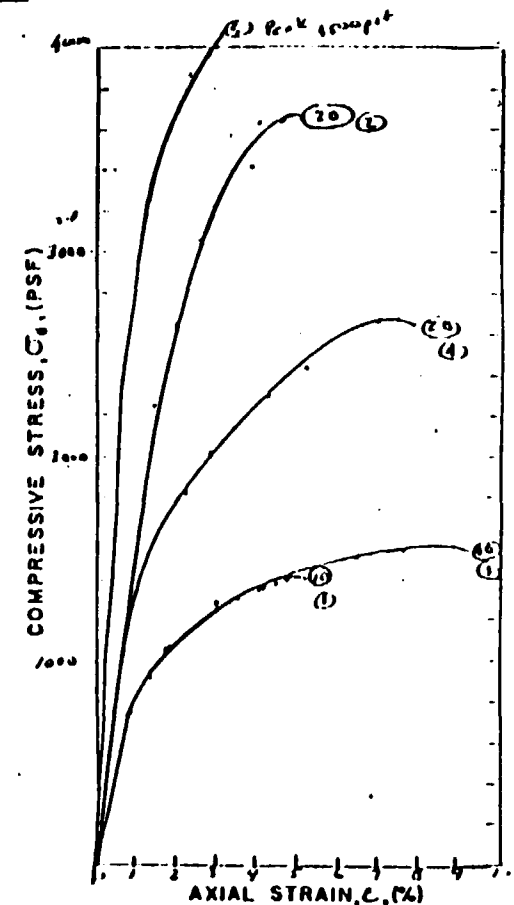
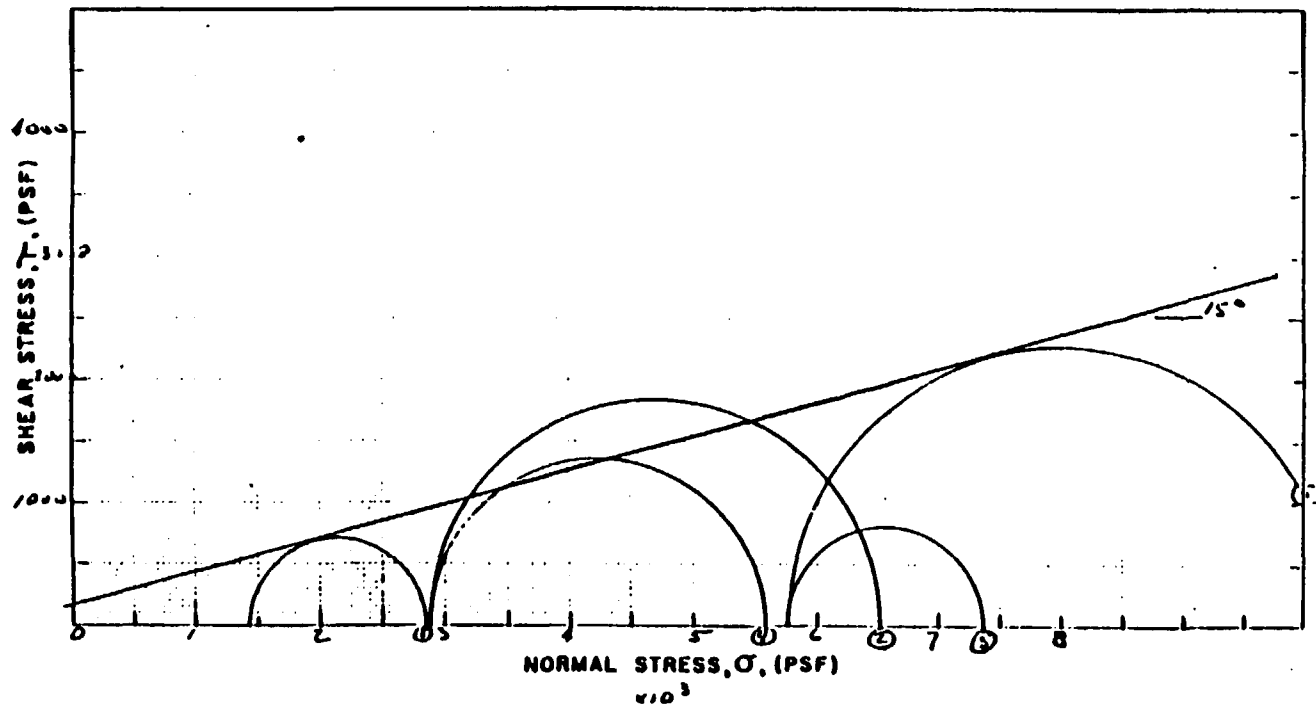
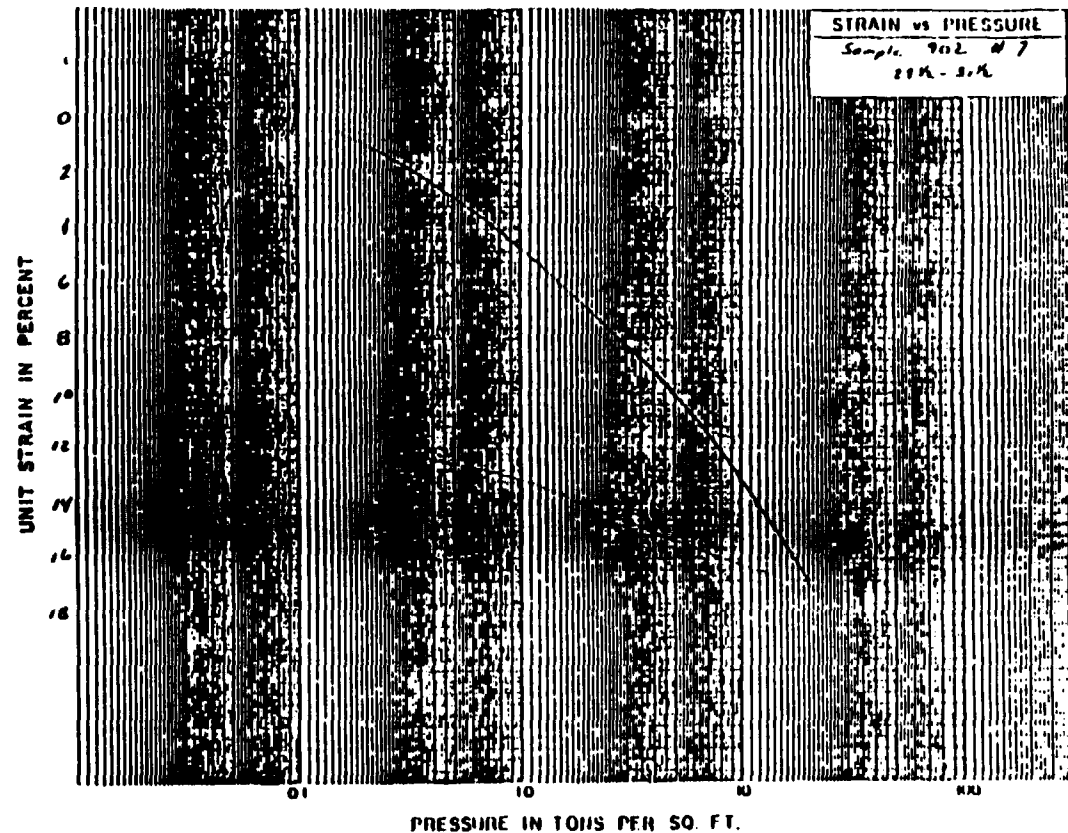
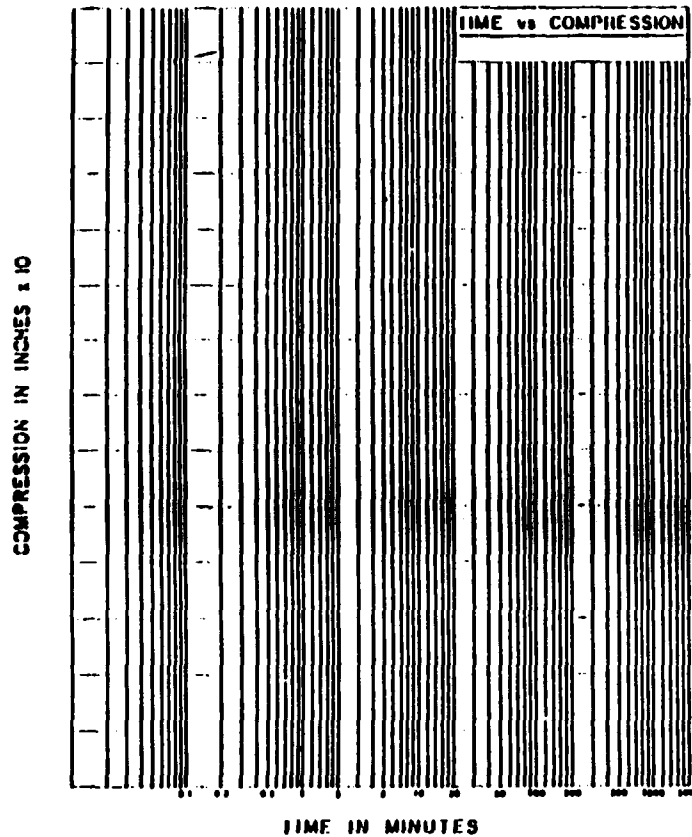


TABLE 3.5-3
CONSOLIDATION TEST OF ASBESTOS MOUND
MILLINGTON SITE



PRESSURE INCREMENTS OF TIME COMPRESSION CURVES	CURVE NUMBER	PRESSURE FROM (1st)	INCREMENT TO (1st)	COEFFICIENT OF CONS. (cm ² /sec)	DESCRIPTION OF SPECIMEN	TEST SPECIMEN PROPERTIES	
						INITIAL	FINAL
					Brain silty CLAY (Disturbed Sample)		
					COMPRESSION INDEX (UNIT STRAIN)	2.45	21.5
					RECOMPRESSION INDEX (UNIT STRAIN)	2.48	56.18
					SWELLING INDEX	72.5	100
					PRECONSOLIDATION STRESS, 1st	100	0.9040
					EXISTING OVERBURDEN STRESS, 1st	77.2	100
						SAMPLE DIAMETER, in	2.50
						LIQUID LIMIT, %	
						PLASTIC LIMIT, %	
					FROM VOLUMETRIC STRAIN		7.15
						SAMPLE HEIGHT, in	
						UNIT DRY WEIGHT,pcf	
						SATURATION, %	
						VOID RATIO	
						WATER CONTENT, %	

1. A slip mechanism is postulated. In the simpler configurations, the slopes are assumed to fall along planes or circular sliding surfaces. When conditions are not uniform, more complex shapes are known to be appropriate, and analyses have been developed to handle surfaces of arbitrary shape.
2. The shearing resistance required to equilibrate the assumed slip mechanism is calculated by means of statics. The potential slip mass is in a state of limiting equilibrium and the failure criterion of the soil or rock is satisfied everywhere along the proposed surfaces. Various methods differ in the degree to which the conditions for equilibrium are satisfied.
3. The calculated shearing resistance required for equilibrium is compared with the available shear strength. The comparison is made in terms of factor of safety, defined as follows: "The factor of safety is that factor by which the shear strength parameters may be reduced in order to bring the slope into a state of limiting equilibrium along a given slip surface." According to this definition, the factor of safety relates to the strength parameters and not to the strength itself. Moreover, by this definition, the factor of safety is uniform along the entire slip surface.
4. Successive iterations are used to find the lowest factor of safety. For example, if it is assumed that the slip surface is circular, a search is made for the critical slip circle.

The stability analysis for this site was performed for a one hundred (100) foot section across the southeastern portion of the site as shown in Figure 3.5-1. This section was considered to be the most critical case due to the steepness of the slopes and their close proximity to the Passaic River. The subsurface stratigraphy and existing groundwater level

was inferred from monitoring wells 902, 903, 904 and 907. The assumed groundwater level, which is located higher than the existing groundwater level, was used for the most conservative analysis in the event the water level may fluctuate.

The material properties and strength values for the asbestos was obtained from laboratory tests conducted on relatively undisturbed asbestos samples (See Section 3.5.2.3 for complete results). The material properties and strength values for the soil and rock zones were assumed based on lab data and empirical correlations for strength parameters based on Standard Penetration Resistance values obtained during the drilling program. The existing slope was analyzed for stability under both static and dynamic (with earthquake loads) conditions.

See Appendix D for the complete analysis.

3.5.3.3 Findings. The factor of safety of the existing slope under static conditions was calculated to be 0.96. The seismic analysis for the same slope, considering earthquake coefficient for horizontal acceleration as 0.10, and neglecting coefficient for vertical acceleration and cavitation pressure, gave a factor of safety of 0.82. See Figure 3.5-2 for the potential critical failure surfaces. When a slope has failed, the factor of safety is unity, which indicates by this analysis that the existing slope is in an unstable state and the risk of a possible landslide exists. As described in Section 3.5-4, these findings were not substantiated in additional engineering studies of the asbestos mound.

The stability of a slope can be improved by cutting back the slope to a safer, more stable angle. Numerous slopes were analyzed using the same material properties and strength values for the asbestos, soil and rock but varying the slope angle, until an adequate factor of safety was obtained. In general, a factor of safety of 1.5 for static conditions, and a factor of safety of 1.2 for dynamic conditions, is considered acceptable. By trial and error, it was found that a two and one half (2.5) horizontal to one (1) vertical slope is stable with a factor of safety of 1.6 for static conditions and 1.3 for dynamic conditions. See

Appendix D for the complete analysis and Figure 3.5-2 for the potential critical failure surfaces.

3.5.4 Additional Engineering Investigation

3.5.4.1 Purpose. As an addendum to the Site Operations Plan, additional engineering studies were conducted at the asbestos mound to confirm the results of the preliminary investigation and further evaluate the stability of the unit.

3.5.4.2 Methodology. Four (4) additional test borings were drilled at the site, as presented on Figure 3.5-3. Hollow stem augers were used to advance each of the borings. Samples of asbestos/soil were collected using both split-spoon and Shelby Tube samplers. Initially, a spilt-spoon sample was collected, and then the augers advanced to the bottom of the sampling interval. A Shelby Tube sample was then collected from the in-situ material. This alternating sampling procedure continued from the ground surface to native soil in each of the test borings. Collected samples were then transported to a geotechnical laboratory for subsequent testing. Logs of the test borings are included in Appendix D.

All spilt-spoon samples were tested for natural moisture content to evaluate variability of physical characteristics of asbestos with depth. A comparison of this data is provided on Figures 3.5-4 and 3.5-5. Upon completion of these tests, undisturbed Shelby Tube samples were then identified which were judged to be representative of depths with extremes of natural moisture content. These samples were also anticipated to represent extremes of strength properties. These samples were then used for Consolidated Undrained Triaxial Testing. In addition, a series of Unconsolidated Undrained Triaxial Tests were conducted on undisturbed samples to obtain a representation of the complete range of natural moisture contents. The results of the triaxial testing, as well as moisture content evaluations of the split-spoon samples are included in Appendix D.

ASB 002 0848

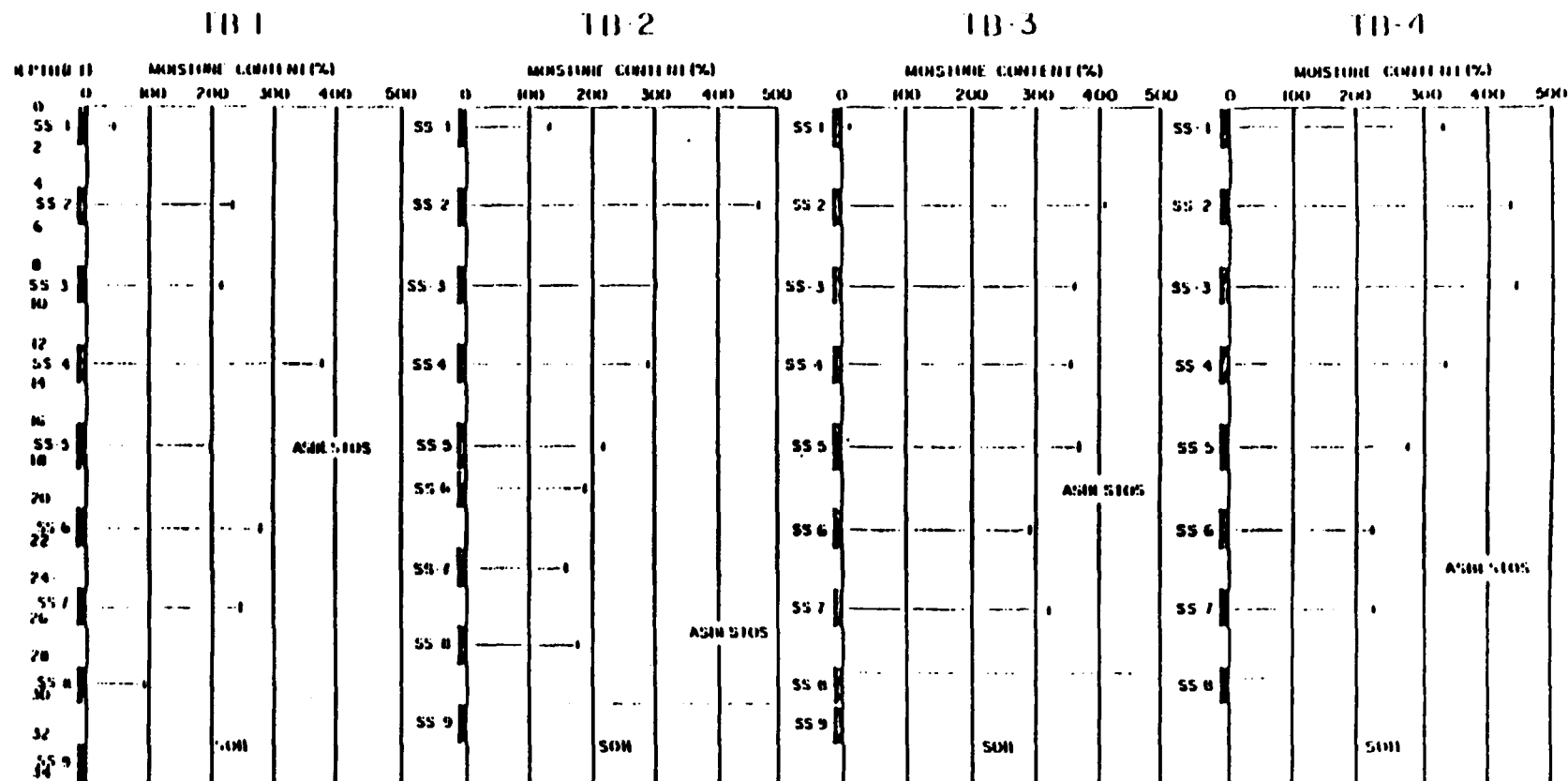


FIGURE 3.5-4
NATURAL MOISTURE CONTENT
VS.
DEPTH IN ASBESTOS
(INDIVIDUAL BORINGS)

FRED C. HART ASSOCIATES, INC.

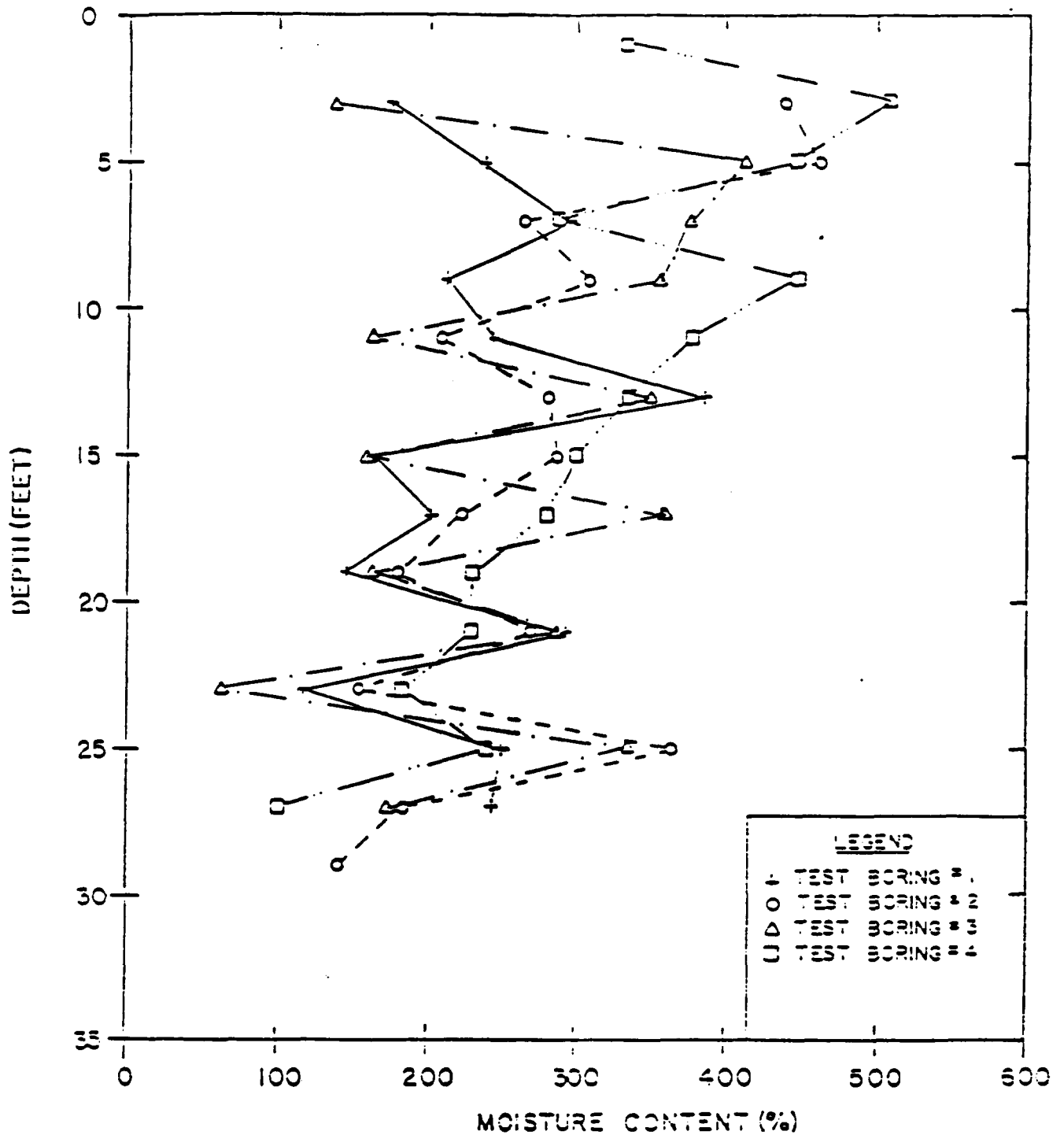


FIGURE 3.5-5
NATURAL MOISTURE CONTENT
VS.
DEPTH IN ASBESTOS
(COMPOSITE DATA)

FRED C. HART ASSOCIATES, INC.

A field reconnaissance was also conducted to identify any areas of surficial sloughing or erosion, as well as to qualitatively evaluate the vegetative growth on the slope. One surficial slough was identified where asbestos materials were exposed to the surface; the approximate location of this slough is shown on Figure 3.5-3.

Additional topographic coverage was obtained for the site to permit more accurate determination of critical slope areas for future slope stability analysis. The location of the surficial slough observation during the field reconnaissance was field surveyed for subsequent location on the topographic map, as discussed previously.

3.5.4.3 Findings. Of primary importance to the stability analyses for the embankment are the strength characteristics of the asbestos. The triaxial testing conducted as part of this additional study was intended to provide confirming data for the strength parameters estimated in the previous study. Results of the additional triaxial testing are included in Appendix D as previously discussed.

Test results for triaxial testing of soils are typically reported as plots of normal stress versus shear stress, such that the slope and Y-intercept of the Mohr envelope can be determined. The intercept value and slope are identified as cohesion "C" and angle of internal friction " ϕ ", respectively, and are the strength parameters used in stability analyses. In the case of the data obtained during the triaxial testing, the test curves plotted are of insufficient consistency to assign corresponding "C" and " ϕ " values. This irregularity was present in both sets of Consolidated Undrained Triaxial Tests conducted, and do not provide support for the values determined in the limited previous study used to evaluate slope stability. The additional Unconsolidated Undrained Triaxial Tests were conducted to determine if there was any obvious relationship between material strength and natural moisture content. The results indicated that such a relationship was not readily identifiable.

Test variability similar to these results generally occurs in soils where the samples do not remain truly "undisturbed" during sample

retrieval, and where soil structure within the sample is disrupted. This is particularly true with sensitive soils. Considering the fibrous nature of asbestos, the physical characteristics may be best approximated by those of a sensitive peat soil. Sensitive peats are particularly difficult to sample in a completely undisturbed condition, and are likely to display significant strength variability between tests. As a rough comparison of physical properties between asbestos and peat, a graph of unit dry weight versus moisture content was developed, as presented as Figure 3.5-6. Since the physical properties compare favorably, and both material are unique in having significant fibrous constituents, it is possible that in-situ sampling or testing procedures for peat will produce more accurate and repeatable test results than the procedures commonly applied to soils, as were used for sampling the asbestos during these previous studies.

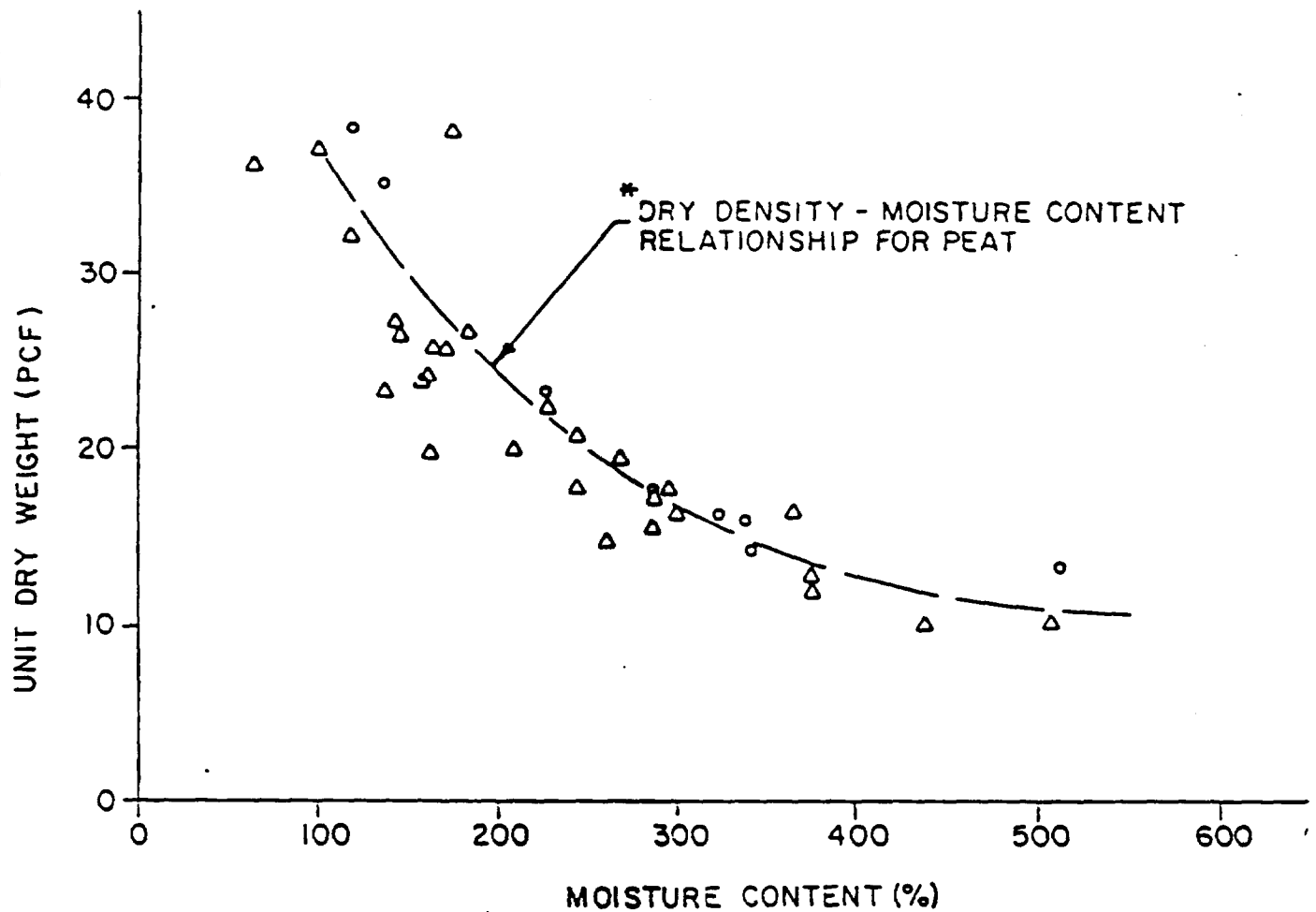
3.5.5. Slope Revegetation Potential

3.5.5.1 Purpose. In order to determine the feasibility of slope revegetation of the asbestos mound at the Millington Site as a means of increasing stability, two surface soil samples were collected and analyzed to determine if they would support ground cover.

3.5.5.2 Methodology. Two composite soil samples were collected from random locations along the surface and slope of the asbestos mound. Instruments used in the collection of the two soil samples consisted of a stainless steel trowel and bowl. Prior to their utilization these instruments were cleaned in the following manner:

- soap and water wash.
- distilled water rinse.
- wrapped in aluminum foil.

Immediately following the collection of the composited soil samples, each sample was placed in a sample bag provided by the U.S. Department of Agriculture and mailed to the Cooperative Extension Service at Cook College, Rutgers University in New Brunswick, N.J. for analysis.



○ LAB RESULTS FROM SAMPLES OBTAINED DURING NOV. 87 MONITORING WELL INSTALLATION
 △ LAB RESULTS FROM SAMPLES OBTAINED DURING NOV. 87 GEOTECHNICAL INVESTIGATION

* THE SYMPOSIUM ON TESTING OF PEATS AND ORGANIC SOILS, TORONTO, CANADA, JUNE 23, 1982, "GEOTECHNICAL PROPERTIES OF PEAT IN SAN JOAQUIN DELTA," MARACHI, DAYTON AND DARE, PAGE 209

FIGURE 3.5-6
 NATURAL MOISTURE CONTENT
 VS.
 UNIT DRY WEIGHT
 (COMPOSITE DATA)

FRED C. HART ASSOCIATES, INC.

ASB 002 0853

3.5.5.3 Findings. The results of the analyses of the two in-situ soil samples of their potential to support ground cover are presented in Appendix D. The analyses indicate that the soils are capable of supporting ground cover and that this ability can be enhanced with the addition of fertilizer.

3.5.6 Test Pit Excavations

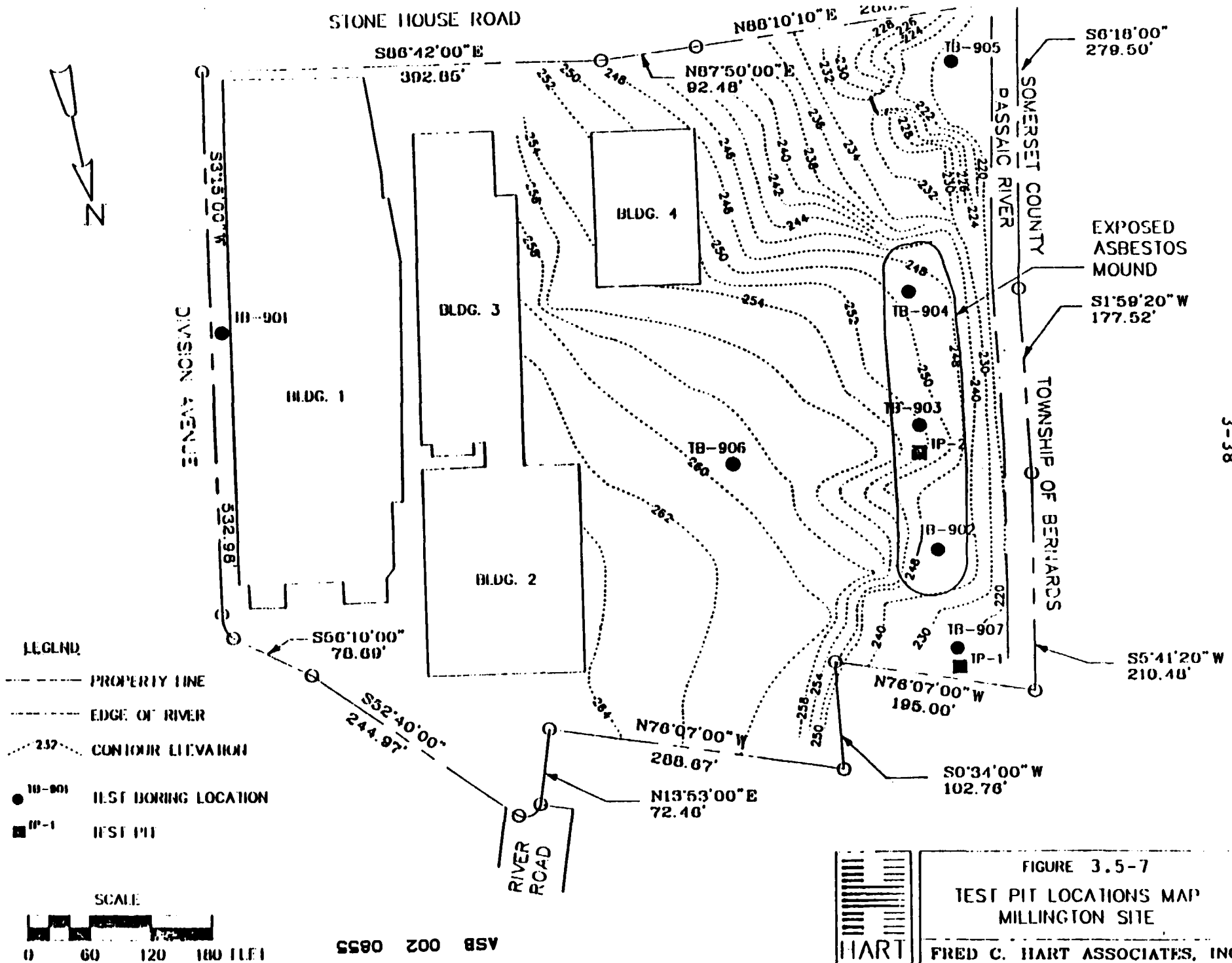
3.5.6.1 Purpose. Test pits were constructed during the engineering investigation to detail the spoil (landfilled asbestos) and in-situ materials on and next to the asbestos waste mound. Information generated from this investigation will be used in conjunction with other data generated during the engineering investigation to assess the structure/stability of the asbestos mound. In addition, this information is needed to help discuss recommendations pertaining to the impacts and remediation of the asbestos mound unit.

3.5.6.2 Methodology. Two test pits (A and B) were constructed at the Millington Site with the use of a rubber-tire backhoe, (Figure 3.5-7). Test pit A was constructed north of the asbestos mound and test pit B on the center of the asbestos mound. The size of the test pit excavations were approximately 7 feet wide x 7 feet long x 10 feet deep. Both test pits were constructed in a safe and proper manner in accordance with the Site Health and Safety Plan. The areas under excavation were constantly wetted down during the test pit construction to minimize the hazards of airborne asbestos fibers.

Following the completion of each test pit, the site geologist recorded all observations and materials encountered in the field test pit logs. After each test pit was constructed and all information logged, the test pits were backfilled with the excavated materials.

3.5.6.3 Findings. Test pit logs prepared by HART personnel are contained in Appendix E.

ASB 002 0854



3.6 Permeability Testing

3.6.1 Purpose. Hydraulic conductivity (K) is the rate at which a fluid of standard viscosity can move through a given distance at a given interval of time. In order to determine the average hydraulic conductivity values of underlying geologic formations, HART conducted aquifer tests at the Millington Site. Aquifer tests were performed on four monitoring wells. Three of the four wells (903, 905, 907) are four and one quarter inches in diameter screened in unconsolidated material, and one well (901) is six and one eighth inches in diameter constructed in siltstone bedrock.

3.6.2 Methodology. A single borehole permeability test known as the Slug Test was implemented at the aforementioned sites. Initially, using an electronic water level indicator, the static water level (H) in each well was measured and recorded. Afterwards, a properly decontaminated PVC slug was lowered into each well displacing a known volume of water. Depending on the length of water column in the well screen, one of two methods was used to generate slug test data. The first method involved allowing the water levels to return to their static level (H), or equilibrium. After the wells reached equilibrium, the slug would be removed thereby initiating the test. The second method involved implementing the slug test at the instant the slug was introduced into the well. Therefore, the slug, which displaces a known volume of water, was either instantaneously removed from the well, or instantaneously introduced into the well. Afterwards, either the rate of recovery or the rate of recharge in the well was measured at frequent time intervals, using an electronic water level indicator, until equilibrium was reached. The measurements and their respective times were recorded for further calculations.

Static water levels (H) were measured and the instantaneous head change (H_0) for each well was calculated by knowing the volume of water that the slug displaced. Although there is a very slight time-lag between either the removal or the introduction of the slug and the first water level measurement, time zero was assigned to the instant at which the

ASB 002 0856

water was displaced. Thus, the value H_0 is the change in head (H) when the slug is either instantaneously removed from the well or instantaneously introduced into the well. Changes in head with time were measured and recorded. Using these measurements and time zero, the ratio H/H_0 was determined for each recorded measurement. These values were plotted on semi-logarithmic paper with respect to their specific time interval (t) in seconds. Calculations and the plotted graphs are provided in Appendix F.

Data reduction for the monitoring wells followed methods set forth by Hvorslev et al. (1951). After the values for H/H_0 were plotted on semi-logarithmic paper with respect to their specific time interval (t) in seconds, the value of T_0 (basic time lag) is measured graphically where the slope of the plotted line intersects the H/H_0 value of 0.37. Hvorslev (1951) evaluated the shape factor (F) for a piezometer intake of length (L) and radius (R) where $L/R > 8$. Thus, the resulting expression for hydraulic conductivity (K) is:

$$K = \frac{r^2 \ln (L/R)}{2 L T_0}$$

Where:

K = hydraulic conductivity (cm/sec)
 r = radius of casing (cm)
 L = length of piezometer intake (cm)
 R = radius of piezometer intake (cm)
 T_0 = basic time lag (sec)

3.6.3 Findings. The hydraulic conductivity values and transmissibility values determined from the slug test data are provided in Table 3.6-1, and raw data is provided in Appendix F. Note that the hydraulic conductivity values (K) which were determined describe only the hydraulic conductivity of the water bearing material close to each well (Cooper, et al., 1967) and represent an average permeability of the various water-bearing units.

TABLE 3.6-1

HYDRAULIC CONDUCTIVITY VALUES AS
DETERMINED FROM SLUG TEST DATAMILLINGTON SITE

Well Number	Instantaneous Head Change (H_0) (ft)	Basic Time Lag (T_0) (Seconds)	Radius of Casing (cm)	Radius of Intake (cm)	Saturated Thickness (cm)	Hydraulic Conductivity (cm/sec)
901	0.79	124	7.78	7.78	657.45	1.60 E-03
903	1.44	280	5.4	5.4	166.12	1.0 E-03
905	1.44	295	5.4	5.4	166.12	1.02 E-03
907	1.17	245	5.4	5.4	135.03	1.42 E-03

Slug tests were performed on four wells at the Millington Site. Three of the wells were screened in the shallow deposits and one well penetrated the underlying bedrock. The hydraulic conductivity values for the shallow wells at Millington ranged from $1.00 \text{ E-}03 \text{ cm/sec}$ to $1.42 \text{ E-}03 \text{ cm/sec}$, with an average calculated hydraulic conductivity of $1.14 \text{ E-}03 \text{ cm/sec}$. The hydraulic conductivity for the bedrock well was calculated to be $1.60 \text{ E-}03 \text{ cm/sec}$.

The average hydraulic conductivity values at the Millington Site falls within the range of values of hydraulic conductivity for aquifers possessing similar lithologic characteristics (Freeze and Cherry, 1979).

There are a number of general assumptions on which this type of aquifer test is based, such that:

- the well is of finite diameter;
- the well is non-flowing;
- the well is cased to the top of a homogeneous isotropic aquifer of uniform thickness; and
- the well is fully developed and penetrates throughout the thickness of the aquifer.

Few wells completely penetrate an aquifer. However, useful information is derived from a test on a partially penetrating well. Since the vertical permeabilities of most stratified aquifers are only small fractions of the horizontal permeabilities, the direction of flow during the slug test is essentially two-dimensional (Cooper, et al., 1967). Transmissibilities (point hydraulic conductivities) determined from the analysis of slug test data are only representative of the water-bearing material close to the well (Ferris, et al., 1962, and Cooper, et al., 1973). However, as Papadopoulos, et al. (1973) stated:

The test provides an economical means of determining "point" transmissibilities. In some types of groundwater investigations a large number of such point transmissibilities are often of greater use

than a single value of the transmissibility obtained from a long-term pumping test at the same cost. In a properly developed well, the slug test transmissibilities should be higher than the long-term pumping test transmissibility.

Consequently, hydraulic conductivity (K) values are representative of "upper limit" values. In other words, actual aquifer permeabilities would tend to be lower than those approximated by this aquifer test.

3.7 Ambient Air Sampling

During the subsurface investigations, ambient air samples were taken and analyzed for asbestos fiber concentrations. The subsurface investigations consisted of soil borings, well installations, and test pit operations, all of which had the potential to create airborne asbestos fibers by disturbing any asbestos-containing soils. The primary objective of these samples was to determine if significant amounts of asbestos fibers would be released during any excavation that might be undertaken as a remedial action and to predict the air quality impact at the site boundary.

Subsequently, EPA has requested that air samples for asbestos be collected under ambient conditions to determine baseline risks in the Endangerment Assessment. Due to inappropriate weather conditions during the months of January and February 1988, these air samples were not obtained by the time of this report submission. The results of the ambient air sampling in addition to the results from the air sampling performed during the subsurface investigations will be presented in an addendum to the Remedial Investigation Report.

3.8 Surface Water and Sediment Sampling

3.8.1 Purpose. Surface water and sediment samples were collected along the Passaic River (upgradient and downgradient of the Millington Site) to define the nature and extent of off-site surface water and sediment contamination. This sampling was performed as part of a regional

sampling program which included sampling in the vicinity of the three satellite sites in addition to the Millington Site. Regional sampling locations are listed in Table 3.8-1 and shown in Figure 3.8-1. Samples SW-1, SW-2, SW-3, SW-22, SED-1 and SED-2 were collected in conjunction with the Millington Site and are discussed in this report. Results from the other sampling locations will be addressed in a separate RI report for the satellite sites.

Background surface water and sediment samples were taken upstream of the site to represent conditions in the Passaic River. Surface water and sediment samples were also taken downstream of the Millington Site to determine if the site was impacting these media.

The precise location of each sediment sample was dependent on availability and type of depositional sediments along a particular bank and the ability of the sediment coring device to penetrate these sediments. Wherever possible, the types of sediments collected were kept uniform so that site comparisons could be made.

Two additional rounds of surface water samples were collected in June and October 1987 as part of a surface water monitoring program. In addition to the four sampling locations (SW-1, SW-2, SW-3 and SW-22) sampled during the initial surface water investigation, and another sampling location (SW-00) consisting of the storm drain at the Millington Site was investigated to determine the water quality at this location.

3.8.2 Methodology. Surface water samples were taken by submerging a laboratory-cleaned, one liter amber bottle directly into the stream and then pouring the contents into laboratory-supplied bottles with preservatives. A bottle without preservative was filled directly by submerging into the river water. Glassware was laboratory-cleaned according to EPA protocols prior to sampling. All surface water locations were analyzed for pH, specific conductance and temperature. For the initial sampling round, the samples were sent to YWC for Priority Pollutant (PP) plus forty analysis and Princeton Testing Laboratory (PTL) for asbestos fiber counts. The plus forty analysis was used to

TABLE 3.8-1

SURFACE WATER AND SEDIMENT STATION NUMBERS AND LOCATIONS

Passaic River

- Above confluence with Great Brook (SW-8, Sed-5)*
- Directly below confluence with Great Brook (SW-7)
- Intersection with Lord Stirling Road (SW-5, Sed-4)*
- Intersection with Maple Avenue (SW-3)
- Immediately upstream of Millington Site (SW-2, Sed-2)*
- Intersection with Stone House Road (SW-1, Sed-1)*
- Commonwealth Water Company intake (SW-22)

Great Brook

- Upstream of disposal site (SW-23)
- Directly upstream of disposal site (SW-13, Sed-8)*
- Immediately downstream of disposal site (SW-20, Sed-15)*
- Swamp area downstream of disposal site ((SW-11, Sed-7)*; (SW-12 (Dup))
- Intersection with Pleasant Plains Road (SW-9)
- Above confluence with Passaic River (SW-10; Sed-6)*

Black Brook

- Upstream of White Bridge Road Site (SW-16, Sed-11)*
- Downstream of White Bridge Road Site and upstream of alleged discharge of New Vernon Road Ditch (SW-21, Sed-16)*
- Downstream of White Bridge Road Site and alleged ditch discharge (SW-17, Sed-12)*
- Intersection with White Bridge Road (SW-4)
- Above confluence with Passaic River (SW-6)

Drainage Ditch with no connection to Black Brook (near New Vernon Road Site)

- Upstream of the New Vernon Road Site (SW-19, Sed-14)*
- Downstream of the New Vernon Road Site (SW-18, Sed-13)*

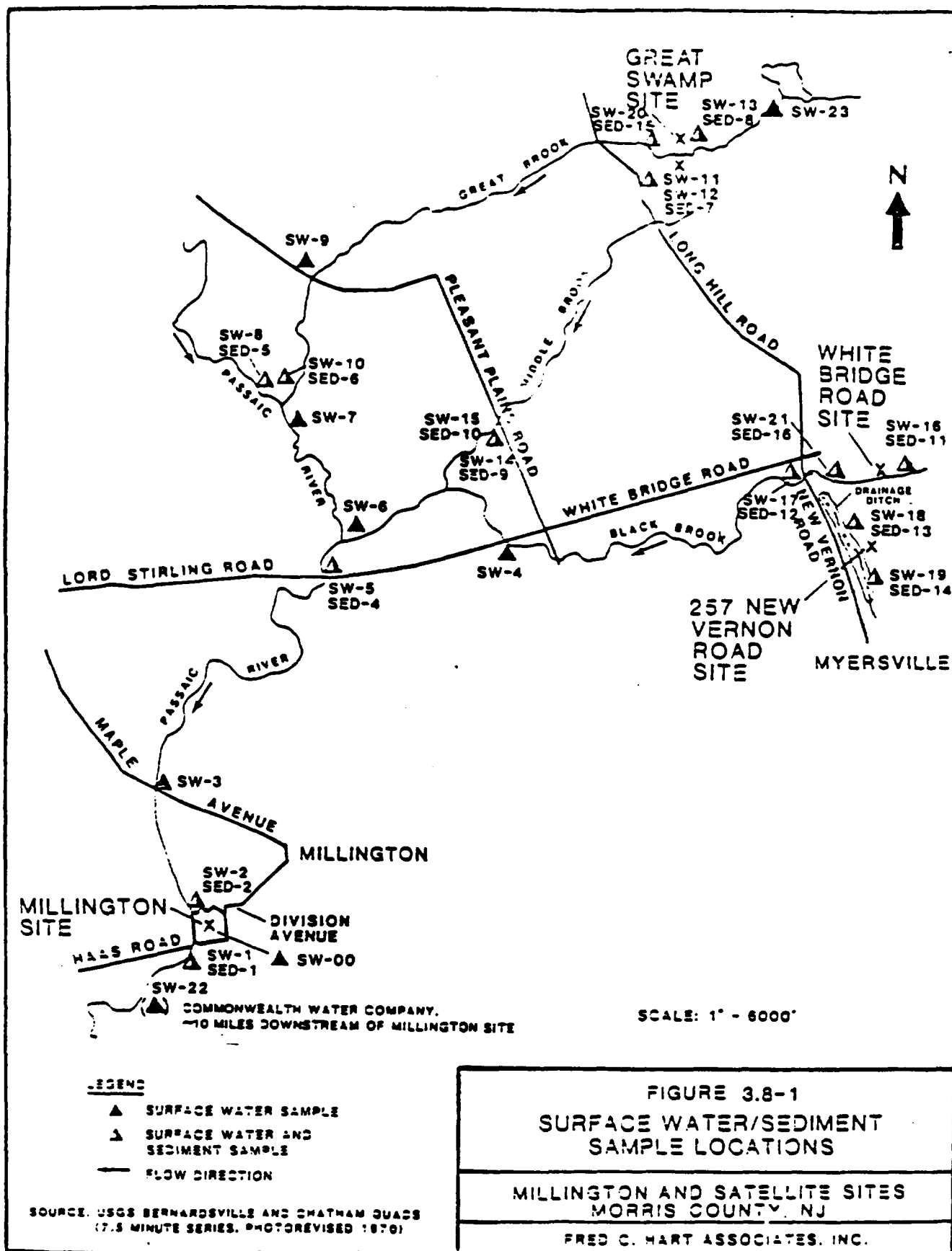
Middle Brook

- Above confluence with Black Brook (SW-14, Sed-9)*
(SW-15, Sed-10 (Dups.))

* Indicates sediment sample collection in addition to water sample collection.

Dup Duplicate Sample

Note: For the second and third rounds of surface water sampling, an additional sample was collected from the storm drain at the Millington Site (SW-00).



tentatively identify the 15 highest volatile organic fraction peaks, the 10 highest acid extractable organic fraction peaks, and the 15 highest base/neutral organic fraction peaks, along with their estimated concentrations using the EPA/NIH/NBS mass spectral library search. Based on the results of the first sampling round, the second and third round of surface water samples were analyzed for PP volatiles plus 15, base neutrals plus 15, metals and asbestos fiber counts.

All aqueous samples for Priority Pollutant analyses were preserved according to EPA protocols and stored immediately on ice following sample collection. All aqueous samples for asbestos fiber counts were collected in clean laboratory-supplied sample bottles and placed in coolers for shipment to the laboratory. Chain-of-custody was maintained on all samples.

For quality assurance purposes, two field duplicates and one distilled water field blank were collected during the regional surface water investigation and analyzed for PP plus forty parameters and asbestos fiber counts. These samples were not collected at the Millington Site and, hence, will not be discussed within the context of this report.

Prior to the initial sampling, all sampling instruments were cleaned using the decontamination procedures described below by YWC and wrapped in heavy gauge aluminum foil for transport to the field. All equipment was decontaminated between samples withalconox detergent, rinsed with tap water, rinsed with distilled water, rinsed with methanol then hexane, and rinsed with deionized water.

Sediment samples were collected using a stainless steel coring device to a depth of at least six inches, where possible. With the exception of volatile organic samples, sediments from each sample location were placed in a clean stainless steel bowl and mixed to homogenize the core samples. Clean trowels or spoons were used to transfer the mixed sediments to the sample jars. Volatile organic samples were collected from the first core sample using clean spoons and placed directly in the VOA vials. The

sediment samples for PP plus forty analysis and asbestos fiber counts were collected in laboratory-cleaned sample bottles provided by YWC and stored on ice immediately after sample collection. All sample bottles were laboratory-cleaned according to EPA protocols.

In addition to the sediment samples, one field duplicate and one field blank were collected. Again, because these samples were collected outside the Millington Site during the regional sediment investigation, they are not discussed in this report.

3.8.3 Findings. The results of the field parameters from the three surface water sampling rounds are presented in Table 3.8-2. Surface water temperatures ranged from 16-17°C during the initial sampling round, 24-25°C during the second sampling round and 12-15°C during the third. Conductivity values for the initial sampling round ranged between 200-710 umhos/cm, 198-340 umhos/cm during the second sampling round and 240-540 umhos/cm during the third. Measurements of pH for the initial sampling task ranged between 6.5-7.3, 5.6-7.2 during the second sampling task and 6.2-6.8 for the third.

Laboratory data sheets, case narratives and a QA/QC review of the data for the surface water samples are contained in Appendix B. A summary of the initial sampling results is presented in Table 3.8-3. Only detected compounds were included. For purposes of comparison, Maximum Contaminant Levels (MCLs) and USEPA Ambient Water Quality Criteria (AWQC) for consumption of aquatic organisms and drinking water are provided in Table 3.8-4.

In the organic fraction of the Priority Pollutants, two base/neutral compounds and phenols were found above detection limits. Bis(2-ethylhexyl)phthalate and di-n-octyl phthalate were indicated at concentrations of 110 ug/l and 13 ug/l, respectively, in SW-3 located upstream up the Millington Site. The bis(2-ethylhexyl)phthalate concentration was below its AWQC of 15,000 ug/l. Phenols were only present in one sample (SW-22) at a concentration of 42 ug/l. Sample SW-22 was obtained at the Commonwealth Water Company intake.

TABLE 3.8-2
SURFACE WATER SAMPLE NUMBERS
AND PHYSICAL PARAMETERS

MILLINGTON SITE

INITIAL SAMPLING ROUND

<u>Date</u>	<u>Station #</u>	<u>Temp (°C)</u>	<u>Cond (umhos/cm)</u>	<u>pH (s.u.)</u>
9/10/86	SW-1	17	230	6.5
9/10/86	SW-2	17	200	6.6
9/10/86	SW-3	17	220	6.6
9/18/86	SW-22	61°F	710	7.3

SECOND SAMPLING ROUND

6/22/87	SW-00	-	-	-
6/23/87	SW-1	25	220	5.6
6/23/87	SW-2	24	205	7.2
6/23/87	SW-3	24	198	6.6
6/23/87	SW-22	-	340	7.1

THIRD SAMPLING ROUND

10/28/87	SW-00	-	280	6.6
10/19/87	SW-1	15	250	6.7
10/19/87	SW-2	-	240	6.8
10/19/87	SW-3	-	280	6.8
10/22/87	SW-22	12	540	6.2

TABLE 3.8-3
SUMMARY OF PRIORITY POLLUTANT DATA

MILLINGTON SITE

SURFACE WATER SAMPLES
INITIAL SAMPLING*

	<u>Sample Number</u>				
	<u>SW-1</u>	<u>SW-2</u>	<u>SW-3</u>	<u>SW-22</u>	<u>TB-1</u> <u>(2811)</u>
<u>Volatile Organics (ug/l)</u>					
Methylene chloride	--	--	--	--	4 J9
<u>Base Neutral Extractables (ug/l)</u>					
Diethyl phthalate	--	NDB	NDB	1J	
Di-n-butyl phthalate	--	NDB	--	--	
Bis(2-ethylhexyl)phthalate	--	--	110	--	
Di-n-octyl phthalate	--	--	13	--	
<u>Phenols (ug/l)</u>	--	--	--	42	
<u>Metals (ug/l)</u>					
Cadmium	563	--	--	--	
Chromium	20N	--	--	--	
Lead	--	--	--	18S	
Nickel	47N	--	--	84	

- * Samples SW-1, SW-2, SW-3, and TB-1 were collected on 9/10/86; sample SW-22 was collected on 9/18/86.
- Indicates compound was analyzed for but not detected.
- J Indicates that the concentration listed is an estimated value which is less than the specified minimum lower limit but is greater than zero.
- B Analyte was found in the method blank as well as in the sample.
- N Indicates spike sample recovery is not within control limits.
- Blank spaces indicate that the sample was not analyzed for those parameters.
- TB Trip Blank
- FB Field Blank
- S Indicates value determined by method of standard addition.
- NDB Value is reported as not detected because compound was found at concentrations less than five times (ten times for common lab contaminants) the amount in any blank associated with sample.

TABLE 3.8-4

APPLICABLE STANDARDS AND CRITERIA FOR SURFACE WATERSafe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs)

Arsenic	50 ug/l
Cadmium	10 ug/l
Chromium	50 ug/l
Lead	50 ug/l
Silver	50 ug/l
Selenium	10 ug/l

USEPA Ambient Water Quality Criteria (AWQC) *(For Consumption of Aquatic Organisms and Drinking Water)

Di-n-butyl phthalate	34,000 ug/l
Bis(2-ethylhexyl)phthalate	15,000 ug/l
Arsenic	.002 ug/l
Copper	1000 ug/l
Mercury	.144 ug/l
Nickel	13.4 ug/l
Zinc	5000 ug/l
Asbestos	30,000 fibers/liter

* USEPA - AWQC for cadmium, chromium, lead, silver, and selenium are equal to their MCL values.

Source: Superfund Public Health Evaluation Manual, 1986.

Priority Pollutant metals were indicated in two samples (SW-1 and SW-22). SW-1, located immediately downstream of the Millington Site, contained three metals. Cadmium was detected in SW-1 at a concentration of 563 ug/l which exceeds the MCL of 10 ug/l for cadmium. Chromium and nickel were also indicated in this sample at concentrations of 20 and 47 ug/l, respectively. SW-22, located ten miles downstream of the Millington Site, contained two metals: lead (18 ug/l) and nickel (84 ug/l). Only the nickel concentrations exceeded its AWQC of 13.4 ug/l.

The second surface water sampling effort occurred during the week of June 19-23, 1987. Table 3.8-2 showed the tested field parameters and the analytical results are presented in Table 3.8-5. Based on the results of the initial sampling round, samples were analyzed for PP volatiles, base/neutrals, metals and asbestos. No PP volatile organics or base neutrals were detected in the second round of sampling results.

The metals analyses indicate that seven metals were detected in concentrations ranging from 2.5-40 ug/l. Lead (2.5-8.6 ug/l) and zinc (8-40 ug/l) were the most frequently detected metals and were indicated in four sample locations as well as in the field blank. The highest concentrations of both metals were found in the storm drain discharge along with arsenic (15 ug/l), copper (14 ug/l) and nickel (24 ug/l). Silver (13 ug/l) was only detected at the Commonwealth Water Company intake (Sample SW-22). Chromium (11-26 ug/l) was indicated in the two upstream sampling locations, SW-2 and SW-3. Only the arsenic and nickel levels in SW-00 exceeded their AWQC of .002 ug/l and 13.4 ug/l, respectively. The arsenic level, however, was below its MCL of 50 ug/l.

The third sampling effort occurred during the week of October 22-25, 1987. Sampling locations consisted of the same five as investigated during the second round sampling effort. Sample parameters included PP volatiles, base neutrals, metals and asbestos. In addition to the surface water samples, two trip blanks were analyzed for volatile organics for quality assurance purposes. The field tested parameters were illustrated in Table 3.8.2 and the analytical results are presented in Table 3.8-6.

TABLE 3.8-5

SUMMARY OF PRIORITY POLLUTANT DATA
MILLINGTON SITE
SURFACE WATER SAMPLES
SECOND ROUND SAMPLING RESULTS*

	<u>SW-00</u>	<u>SW-1</u>	<u>SW-2</u>	<u>SW-3</u>	<u>SW-22</u>	<u>FB-3</u>	<u>TB-6</u>
<u>olatile Organics (ug/l)</u>							
acetone	U	-	-	NDB	-	9JB	7J
benzene	U	NDB	NDB	-	NDB	1JB	1J
ethylene Chloride	U	-	-	-	-	3J	-
<u>Base/Neutral Extractables (ug/l)</u>							
di-n-butyl phthalate	U	NDB	NDB	NDB	NDB	-	
diis(2-ethylhexyl)phthalate	U	-	-	-	-	2JB	
<u>Metals (ug/l)</u>							
arsenic	15R	-	-	-	-	-	
chromium	-	-	26	11	-	-	
copper	[14]	-	-	-	-	-	
lead	8.6SR	[2.8]	[2.8]RQ	[2.5]RQ	-	[4.4]R	
nickel	[24]	-	-	-	-	-	
silver	-	-	-	-	13R	-	
zinc	40ER	[12]	[12]ER	-	[16]ER	[8.0]ER	

Sample SW-00 was collected on 6/22/87; Samples SW-1, SW-2, SW-3, TB-6 were collected on 6/23/87; Samples SW-22 and FB-3 were collected on 6/25/87

Indicates that spike sample recovery is not within control limits.

Indicates that the concentration listed is an estimated value which is less than the specified minimum detection limit but greater than zero.

Analyte was found in the method blank as well as in the sample.

-) Indicates compound was analyzed for but not detected.

] Value is greater than or equal to the instrument detection limit but less than the contract required detection limit.

Value estimated due to the presence of interference.

1 Field Blank

1 Trip Blank

Indicates value determined by method of standard addition.

13) Value is reported as not detected because compound was found at concentrations less than five times (ten times for common lab contaminants) the amount in any blank associated with sample.

Data is unuseable due to QA/QC problems in the laboratory.

Blank space indicates that sample was not analyzed for that parameter.

1205P:14)

0280 200 8SV

021288

TABLE 3.8-6

SUMMARY OF PRIORITY POLLUTANT DATA
MILLINGTON SITE
SURFACE WATER SAMPLES
THIRD ROUND SAMPLING RESULTS

<u>Volatile Organics</u> <u>(ug/l)</u>	<u>SW-00</u> <u>(10-20-87)</u>	<u>SW-1</u> <u>(10-20-87)</u>	<u>SW-2</u> <u>(10-20-87)</u>	<u>SW-3</u> <u>(10-20-87)</u>	<u>TB-6</u> <u>(10-20-87)</u>	<u>SW-22</u> <u>(10-22-87)</u>	<u>TB-8</u> <u>(10-22-87)</u>	<u>FB 3-2</u> <u>(10-22-87)</u>
Acetone	-	-	-	-	-	NDB	6.5 BJ	-
Benzene	NDB	-	-	-	-	NDB	1.4 BJ	-
Methylene chloride	3.1	-	-	-	-	NDB	1.1 J	1.38J
<u>Base/Neutrals</u> <u>(ug/l)</u>								
Dis(2-ethylhexyl)phthalate	NDB	NDB	NDB	NDB	-	-	-	1.78J
Di-n-butyl phthalate	-	NDB	NDB	NDB	-	-	-	7.18
<u>Metals (ug/l)</u>								
Copper	8.0	8.0	8.0	10.0		-		[22]
Chromium	-	5.0	-	5.0		-		13
Zinc	36.0	14.0	49.0	11.0		60		[16]
Antimony	-	-	-	-		-		[56]
Nickel	-	-	-	-		-		[20]
Selenium	-	-	-	-		20		-

FB Field Blank

TB Trip Blank

B Detected in Reagent Blank

J Estimated value less than minimum detection limit

NDB Value is reported as not detected because compound was found at concentrations less than five times (ten times for common lab contaminants) the amount in any blank associated with sample.

[] Value is greater than or equal to the instrument detection limit but less than the contract required detection limit.

Blank space indicates that sample was not analyzed for that parameter.

The only organic compound detected was methylene chloride (3.1 ug/l) in the storm drain. At low concentrations, the presence of methylene chloride is probably due to lab contamination, since methylene chloride is a common lab contaminant.

The metals analyses indicated the presence of four Priority Pollutant metals in concentrations ranging from 5-60 ug/l. Copper (8-10 ug/l) and zinc (11-60 ug/l) were the most frequently detected metals. Concentrations of copper however, were higher upstream than downstream of the Millington Site. Zinc levels were highest at the Commonwealth Water Company (CWWC) intake (SW-22). Selenium (20 ug/l) was also detected at the CWWC intake. Chromium was detected in SW-1 and SW-3 at 5 ug/l. Of the detected metals, the selenium level at the CWWC intake was the only one which exceeded its MCL of 10 ug/l.

Surface water asbestos sampling results for all three rounds of sampling are summarized in Table 3.8-7 and provided in Appendix G. In the first round of sampling, SW-3, located upstream of the Millington Site contained 100,000 fibers/liter of asbestos. In the second round, asbestos was not indicated above detection limits in any of the samples. In the third round, the laboratory was able to achieve lower detection limits (50,000 fibers per liter) in five out of six sample. Asbestos was detected at 67,200 fibers/liter in SW-1 and 71,400 fibers/liter in SW-2. Thus, higher concentrations of asbestos were found upstream than downstream of the Millington Site.

Field descriptions of the sediment samples collected up and downstream of the Millington Site are listed in Table 3.8-8. Sediments in the vicinity of the Millington Site were gravels. Organic analytical results for the sediment samples are summarized in Table 3.8-9. Inorganic data for the sediment samples is found in Table 3.8-10. Sediment sample locations were presented in Figure 3.8-1. Laboratory data sheets, case narratives and a QA/QC review of the sediment data are provided in Appendix B.

TABLE 3.8-7

SUMMARY OF SURFACE WATER ASBESTOS DATA*
MILLINGTON SITE

<u>Sample #</u>	<u>First Round</u>	<u>Second Round</u>	<u>Third Round</u>
SW-00	-	<100,000	<200,000
SW-1	<100,000	<100,000	67,200
SW-2	<100,000	<100,000	71,400
SW-3	100,000	<100,000	< 50,000
SW-22	<100,000	<50,000	< 50,000
Field Blank	<100,000 (FB-2)	<100,000 (FB-3-1)	< 50,000 (FB-3-2)

* Concentration are in fibers (>5 microns) per liter.

TABLE 3.8-8

SEDIMENT SAMPLE NUMBERS AND DESCRIPTIONMILLINGTON SITE

<u>Date</u>	<u>Station #</u>	<u>Sample #</u>	<u>Location</u>	<u>Depth Corer</u>	<u>Description</u>
9-10	Sed-1	2510	West Bank	4-6"	gravels
9-10	Sed-2	2511	East Bank	10"	gravels

TABLE 3.8-9
SUMMARY OF ORGANIC DATA
MILLINGTON SITE
SEDIMENT SAMPLES*

	<u>Sample Number</u>		
	<u>SED-1</u>	<u>SED-2</u>	<u>TB-1</u>
<u>Volatile Organics (ug/kg)</u>			
Methylene chloride	NDB	NDB	4JB
Chloroform	2JB	4JB	--
Benzene	--	1J	--
Toluene	12B	15B	--
<u>Base Neutrals (ug/kg)</u>			
Naphthalene	--	8J	
Acenaphthylene	--	32J	
Acenaphthene	16J	14J	
Diethyl phthalate	51J	54J	
Fluorene	20J	28J	
Phenanthrene	210J	560	
Anthracene	55J	82J	
Di-n-butyl phthalate	52JB	81JB	
Fluoranthene	400	1400	
Pyrene	320J	1200	
Chrysene	210J	840	
Benzo(a)anthracene	--	660	
Bis(2-ethylhexyl)phthalate	140JB	130JB	
Benzo(b)fluoranthene	--	1300	
Benzo(k)fluoranthene	--	170J	
Benzo(a)pyrene	150J	590	
Benzo(g,h,i)perylene	--	500	
Indeno(1,2,3,c,d)pyrene	--	460	
<u>Phenols (mg/kg)</u>	--	1.0	
<u>Pesticides/PCBs (ug/kg)</u>			
Heptachlor	5.7J	--	

- * Samples were collected on 9/11/86.
 -- Indicates compound was analyzed for but not detected.
 J Indicates that the concentration listed is an estimated value which is less than the specified minimum lower limit but is greater than zero.
 B Analyte was found in the method blank as well as in the sample. Blank space indicates that the sample was not analyzed for that parameter.
 TB Trip Blank
 NDB Value is reported as not detected because compound was found at concentrations less than five times (ten times for common lab contaminants) the amount in any blank associated with sample.

TABLE 3.8-10
SUMMARY OF INORGANIC DATA
MILLINGTON SITE
SEDIMENT SAMPLES**

<u>Metals (mg/kg)</u>	<u>Sample Number</u>	
	<u>SED-1</u>	<u>SED-2</u>
Arsenic	--	10.9
Chromium	25.6	29.2
Copper	29.0*	67.2*
Lead	33.2R	62.0R
Mercury	--	0.36
Nickel	32.1*	28.8*
Zinc	108	181

-- Indicates compound was analyzed for but not detected.
 * Indicates duplicate analysis is not within control limits.
 R Indicates spike sample recovery is not within control limits.
 ** Samples were collected on 9/11/86.

The sediment samples contained three volatiles: chloroform, benzene and toluene. Chloroform (2-4 ug/kg) was detected in both sediment samples but at estimated values below the detection limit. Toluene was found at levels of 12 and 15 ug/kg. Because both compounds were also present in the method blank, their presence in the samples is probably due to laboratory and/or field contamination. Benzene was were found at an estimated level (1 ug/kg) below minimum detection limits in the upstream sample (SED-2).

Detected base/neutral compounds consist of eighteen constituents that ranged in concentration from 8-1400 ug/kg. Sample SED-1, collected immediately downstream of the Millington Site, contained eleven base/neutral constituents. Fluoranthene was detected in this sample at a concentration of 400 ug/kg. The remaining detected constituents were present in concentrations lower than the minimum detection limit and in some cases were also present in the method blank. Sample SED-2, located immediately upstream of the Millington Site, contained eighteen base/neutral constituents. Half of these constituents were detected at concentrations below the minimum detection limit and two of these compounds were also present in the method blank. The remaining indicated constituents were polynuclear aromatic hydrocarbons (PAHs) which were detected at concentrations ranging from 460-1400 ug/kg. Two common sources of PAHs are roadside runoff and degradation of biota.

Two other organics were detected in the sediments. Phenols were indicated in SED-2 at 1 mg/kg and the pesticide, heptachlor, was indicated in SED-1 at an estimated value of 5.7 ug/kg. The presence of this pesticide may be the result of run-off from adjacent cultivated land.

As shown in Table 3.8-10, seven metals were detected in the sediment samples at concentrations ranging from 0.36 - 181 mg/kg. All seven metals were detected in the upgradient sample (SED-2) while only five metals were present in the downgradient sample (SED-1). Only mercury, which was detected in the upgradient sample (SED-2) was present at a concentration

(0.36 mg/kg) above background levels for natural soils (Table 3.2-5). With the exception of nickel, metals concentrations were higher upstream than downstream.

Asbestos sampling results for sediment samples are contained in Appendix G. No asbestos fibers were detected in the sediment samples.

3.9 Groundwater Sampling

3.9.1 Purpose. The purpose of this task was to assess the presence and extent of groundwater contamination at the Millington Site. During the first round of sampling from November 13-20, 1986, HART collected a total of nine samples including one duplicate and field blank. Two additional rounds of groundwater samples were collected in June and October, 1987 to determine if there were temporal variations in groundwater contamination.

3.9.2 Methodology. In order to ensure the sampling of formation water in the wells, the wells were evacuated by bailing with laboratory-cleaned stainless steel bailers until the conductivity and pH stabilized. In general, no more than 3 to 5 volumes of water were removed during well evacuation.

The samples were collected with a certified laboratory-cleaned stainless steel bottom-loading bailer, with teflon check valve. Each bailer was fitted with a teflon-coated stainless steel cord, and dedicated to one well for evacuation and sample collection. The samples were poured directly from the bailers to the appropriate laboratory supplied glassware which was cleaned according to EPA protocols.

Field-filtering of all groundwater samples for dissolved metals analysis was conducted using a Geotech filter unit with disposable 0.45 micron filters. Prior to filtering, the Geotech filter unit was triple

rinsed with groundwater from the well being sampled to ensure that the unit was clean.

For the initial sampling round, the groundwater samples were analyzed for Priority Pollutants (PP) plus 40 parameters and asbestos fiber counts. PP plus 40 parameters analysis was provided by YWC. Princeton Testing Laboratory (PTL) performed the asbestos fiber counts analysis. For the second and third sampling rounds, the groundwater samples were analyzed for PP volatiles plus 15, base neutrals plus 15, total and dissolved metals, and asbestos fiber counts.

For quality assurance purposes, one duplicate and one field blank were collected for analysis of the same parameters as the samples. The field blank was prepared from laboratory distilled water provided by the laboratory. The field blanks were subjected to the same sampling techniques as the groundwater samples and submitted to the laboratories for analysis. In addition, trip blanks for PP volatile organics were provided and analyzed by the laboratory.

All groundwater samples were carefully packed on ice for shipment to the laboratory. Proper chain-of-custody and QA/QC procedures were followed when transferring samples from the field to the laboratories. In addition, accurate records were kept of all sampling activities, and included the following information: Date, location, sample number, depth to water measurement and volume of water evacuated.

3.9.3 Findings. Groundwater sampling parameters (pH, conductivity, and well volumes removed) are provided in Table 3.9-1. Laboratory data sheets, case narratives and a QA/QC review of the groundwater data is contained in Appendix B. Laboratory data sheets for asbestos analyses are provided in Appendix G. Only detected parameters have been included in the data summary tables. All positive confirmations of any parameters were compared with the following standards or criteria: Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs), New Jersey Department

TABLE 3.9-1
GROUNDWATER SAMPLING PARAMETERS
MILLINGTON SITE
INITIAL SAMPLING ROUND

<u>Well No.</u>	<u>Date</u>	<u>Final pH (s.u.)</u>	<u>Final Conductivity (umhos/cm)</u>	<u>Field Temp (°C)</u>	<u>Well Volumes</u>
901	10/14/86	6.6	820	-	3
902	10/10/86	9.0	1,050	-	3
903	10/14/86	9.2	1,600	-	5 (Dry)
904	10/14/86	7.9	1,150	-	5 (Dry)
905	10/14/86	6.8	560	-	5 (Dry)
906	10/10/86	7.6	980	-	3
907	10/10/86	7.4	805	-	3

SECOND SAMPLING ROUND

901	6/22/87	-	800	15	2 (Dry)
902	6/23/87	9.0	820	14	4
903	6/23/87	11.4	1800	17	3
904	6/23/87	-	1400	14	3
905	6/22/87	-	720	16	4
906	6/22/87	-	950	14	3
907	6/22/87	-	800	14	2 (Dry)

THIRD SAMPLING ROUND

901	10/19/87	6.9	710	-	3
902	10/19/87	9.6	820	-	3
903	10/19/87	10.9	2400	-	3
904	10/20/87	11.1	1100	14	3
905	10/19/87	6.3	480	15	3
906	10/19/87	7.2	100	18	2 (Dry)
907	10/19/87	6.4	900	-	2 (Dry)

- Parameter not obtained

of Environmental Protection (NJDEP) groundwater quality standards, U.S. Environmental Protection Agency (EPA) Ambient Water Quality Criteria (AWQC) for consumption of drinking water only and the USEPA Proposed Maximum Contaminant Level Goals (MCLGs). These standards and criteria are presented in Tables 3.9-2 and 3.9-3.

The analytical results for the initial groundwater sampling task at the Millington Site are summarized in Table 3.9-4. The data is presented for seven monitoring well samples plus one duplicate (908), one trip blank and one field blank. No volatile organic results are presented for Sample 902 because of a system hardware failure at the laboratory (see Appendix B).

The metals data indicates that only three total metals (mercury, nickel, zinc) were detected in the groundwater, but that concentrations of the former two metals exceed some of the standards or criteria. Mercury was detected in six of the seven monitoring wells and in the duplicate of MW-905 at concentrations ranging from 0.2-6.9 ug/l. The concentration of mercury in MW-905 (5.6 ug/l), MW-906 (2.1 ug/l), MW-907 (2.5 ug/l) and MW-908 (6.9 ug/l) exceeds the NJDEP-GWQS and MCL of 2 ug/l. Nickel was only present in MW-907 at a concentration of 49 ug/l which is above the AWQC of 15.4 ug/l. Zinc (28-108 ug/l) was present in every monitoring well sampled at concentrations that are within acceptable levels for groundwater.

Four volatile organic compounds were detected in groundwater samples at concentrations ranging from 2-6 ug/l. Trichloroethene was detected in two wells, MW-903 and MW-905, at an estimated value of 3 and 6 ug/l, respectively. Although both values exceed the AWQC of 2.8 ug/l, only the concentration in MW-905 exceeds the MCL of 5 ug/l. Trans-1-2-dichloroethene was detected in MW-903 at 6 ug/l which is below the MCLG. Estimated values of benzene (2 ug/l) and toluene (2 ug/l) were indicated in MW-904 and MW-905, respectively. Although the benzene concentration exceeded the AWQC of 0.67 ug/l, it was below the MCL of 5 ug/l.

TABLE 3.9-2

GROUNDWATER QUALITY STANDARDS AND CRITERIA - METALS

<u>Analyte</u>	<u>NJDEP</u> <u>GWQS</u> (ug/l)	<u>SDWA</u> <u>MCLs</u> (ug/l)	<u>USEPA</u> <u>AWQC</u> (ug/l)
<u>Metals</u>			
Arsenic	50.0	50.0	.025
Cadmium	10.0	10.0	10.0
Chromium	50.0	50.0	50.0
Copper	1000.0	-	1000.0
Lead	50.0	50.0	50.0
Mercury	2.0	2.0	10.0
Nickel	-	-	15.4
Selenium	10.0	10.0	10.0
Silver	50.0	50.0	50.0
Zinc	5000.0	-	5000.0

NJDEP New Jersey Department of Environmental Protection
 GWQS Groundwater Quality Standards
 SDWA Safe Drinking Water Act
 MCL Maximum Contaminant Level
 AWQC Ambient Water Quality Criteria (adjusted for drinking water only)
 - Indicates that no standard or criteria has been established for
 that constituent.

Source: Superfund Public Health Evaluation Manual, 1986.

TABLE 3.9-3

GROUNDWATER QUALITY STANDARDS AND CRITERIA - NON-METALS

analyte	NJDEP GWQS (ug/l)	SDWA MCLs (ug/l)	Proposed MCLGs (ug/l)	USEPA AWQC (ug/l)
<u>Volatile Organic Compounds</u>				
Acetone	-	-	-	-
Benzene	-	5	-	0.67
1,1-dichloroethene	-	-	-	-
Ethyl Benzene	-	-	680	2400
Ethylene Chloride	-	-	-	0.19
Toluene	-	-	2000	15,000
trans-1,2-dichloroethene	-	-	70	-
1,1-chloroethene	-	5	-	2.8
1,1-chlorofluoromethane	-	-	-	-
Chloroethenes	-	-	440	-
<u>Inorganic Neutral Compounds</u>				
Bis(2-ethylhexyl)phthalate	-	-	-	21,000
Diethyl benzylphthalate	-	-	-	-
n-butylphthalate	-	-	-	44,000
Urethane	-	-	-	188
1-methylnaphthalene	-	-	-	-
Phthalene	-	-	-	-
<u>Pesticides</u>				
Endrin	4.0	0.2	-	1.0
Heptachlor epoxide	-	-	7.1 ^a	30,000 fibers/l

DEP New Jersey Department of Environmental Protection
 GWS Groundwater Quality Standards
 SDWA Safe Drinking Water Act
 MCL Maximum Contaminant Level
 CLG Proposed Maximum Contaminant Level Goal
 EPA United States Environmental Protection Agency
 AWQC Ambient Water Quality Criteria (adjusted for drinking water only)
 - Indicates that no standard or criteria exists for that constituent
 Million fibers per liter.

Source: Superfund Public Health Evaluation Manual, 1986.

TABLE 3.9-4

SUMMARY OF PRIORITY POLLUTANT DATA

MILLINGTON SITE
GROUNDWATER MONITORING WELL SAMPLES
INITIAL SAMPLING RESULTS*

	Sample Numbers								FB-1	18-05
	901	902 ^a	903	904	905	906	907	908**	10/10/86	10/10/86
Volatile Organics (ug/l)										
Methylene Chloride	NDB		NDB	NDB	NDB	NDB	NDB	NDB	270B	12B
Trans-1,2-dichloroethene	--		6	--	--	--	--	--	--	--
Chloroform	--		NDB	NDB	NDB	--	NDB	NDB	3JB	4JB
Trichloroethene	--		3J	--	6	--	--	6	--	--
Benzene	--		--	2J	--	--	--	--	1J	--
Toluene	--		--	--	2J	--	--	--	--	--
Base Neutrals (ug/l)										
Di-n-butyl phthalate	--	3J	--	5J	--	1J	--	--	1J	--
Butyl Benzyl phthalate	--	9J	--	2J	--	--	--	--	6J	--
Bis(2-ethylhexyl)phthalate	140	180	--	400	--	--	--	83	--	--
Di-n-octyl phthalate	U	U	U	U	U	U	U	U	U	--
Pesticides/PCBs (ug/l)										
Endrin	.026	--	--	--	--	--	--	--	--	--
Dissolved Metals (ug/l)										
Mercury	0.3	1.2	0.2	--	5.6	2.1	2.5	6.9	--	--
Nickel	--	--	--	--	--	--	49N	--	--	--
Zinc	28	57N	28	52	87N	96N	108N	74	34N	--
Phenols (ug/l)	31	--	18	22	19	48	23	11	19	--

* Samples 902, 906, and 907 were collected on 10/10/86. Samples 901, 903, 904, 905, and 908 were collected on 10/14/86.

-- Indicates compound was analyzed for but not detected.

J Indicates that the concentration listed is an estimated value which is less than the specified minimum lower limit but is greater than zero.

B Analyte was found in the method blank as well as in the sample.

N Indicates spike sample recovery is not within control limits.

** Sample 908 is a duplicate of 905.

Blank spaces indicate that the sample was not analyzed for that parameter.

TB Trip Blank.

FB Field Blank.

^a The volatile data for well 902 was lost due to a system hardware failure at the laboratory.

NDB Value is reported as not detected because compound was found at concentrations less than five times (ten times for common lab contaminants) the amount in any blank associated with sample.

U Data is unuseable due to method blank contamination above CLP limits.

Of the base neutrals, bis(2-ethylhexyl)phthalate was the only compound which was found above detection limits. Concentrations of bis(2-ethylhexyl)phthalate ranged from 83-400 ug/l which are well below the AWQC of 21,000 ug/l. The two other phthalate esters were detected at estimated levels similar to those found in the field blank and were therefore probably present as a result of field/lab contamination.

Only two other compounds were detected in the groundwater samples. Endrin was detected in MW-901 at a concentration of 0.026 ug/l which does not exceed any groundwater standard or criteria. With the exception of MW-902, phenols were detected in every sample at concentrations ranging from 11-48 ug/l. Their presence in the field blank (19 ug/l), however, suggests that they may be present in the samples due to the lab/field contamination.

In addition to Priority Pollutant plus Forty Analysis, all groundwater samples were analyzed for the presence of asbestos fibers. Appendix G contains and Table 3.9-5 summarizes the data for the asbestos analysis conducted on all groundwater samples from the three rounds of sampling. The groundwater asbestos sampling results for the Millington Site indicated no asbestos above the detection limit of 100,000 fibers/liter for the monitoring wells. Thus, asbestos levels at this site were all below the PMCLG of 7.1 million fibers per liter.

The second round groundwater sampling effort was conducted during the week of June 22-25, 1987. The groundwater was sampled for Priority Pollutant (PP) volatile organics plus 15, PP base neutral extractables plus 15, PP metals (dissolved and total) and asbestos fiber counts. Table 3.9-1 presented the field tested parameters and Table 3.9-6 illustrates the analytical data. As a result of QA/QC problems in the laboratory, there is limited organic data available for discussion. Also, the filtered samples for MW-901 (901-F) and MW-908 (908-F) were lost by the laboratory and, hence, analytical data does not exist for these samples.

TABLE 3.9-5

SUMMARY OF GROUNDWATER ASBESTOS DATA**
MILLINGTON SITE

<u>Sample #</u>	<u>First Round</u>	<u>Second Round</u>	<u>Third Round</u>
901	<100,000	<50,000	< 50,000
902	<100,000	79,809	58,800
903	<100,000	88,210	142,000
904	<100,000	Unreadable	< 50,000
905	<100,000	Unreadable	< 50,000
906	<100,000	Unreadable	<200,000
907	<100,000	Unreadable	<200,000
*908	<100,000	Unreadable	<200,000
Field Blank	<100,000	Unreadable	< 50,000
	(FB-1)	(FB2-1)	(FB2-2)

* Duplicate of 905

** Concentrations are in fibers (>5 microns) per liter.

TABLE 3.9-6
SUMMARY OF PRIMARY CONTAMINANT DATA
DECONTAMINATION SITE
(DECONTAMINATION CONTAMINANTS WITH SAMPLES
SITING REPORT SAMPLES 901-15)

Sample Number	Sample Number														
	901-1	902-1	903-1	904-1	905-1	906-1	907-1	908-1	909-1	910-1	911-1	912-1	913-1	914-1	915-1
Volatiles Organics (ug/l)															
Acetone	0	12	17	0	0	0	0	0	0	0	0	0	0	0	0
Benzene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Methylene Chloride	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0
1,2 Dichloroethane	0	0	43	0	0	0	0	0	0	0	0	0	0	0	0
1,1,1 Trichloroethane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Base Neutral Extractables (ug/l)															
Di-n-butyl phthalate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diethyl benzylphthalate	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Di(2-ethylhexyl)phthalate	0	23	63	0	0	0	0	0	0	0	0	0	0	0	0
Fluoranthene	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metals (ug/l)															
Arsenic	-	16.200	14.400	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	-	15	11	19	19	20	21	405	19	15	11	14	16	16	16
Chromium	-	15	11	19	19	20	21	405	19	15	11	14	16	16	16
Copper	-	15	11	19	19	20	21	405	19	15	11	14	16	16	16
Lead	12.000	15	11	19	19	20	21	405	19	15	11	14	16	16	16
Mercury	-	15	11	19	19	20	21	405	19	15	11	14	16	16	16
Nickel	12.000	15	11	19	19	20	21	405	19	15	11	14	16	16	16
Silver	-	15	11	19	19	20	21	405	19	15	11	14	16	16	16
Zinc	12.000	15	11	19	19	20	21	405	19	15	11	14	16	16	16

- a Samples were taken on 6/27/87 and 6/27/89.
 - Indicates compound was analyzed for but not detected.
 J Indicates that the concentration listed is an estimated value which is less than the specified minimum lower limit but is greater than zero.
 d Analyte was found in the method blank as well as in the sample.
 10 Trip Blank.
 10 Field Blank.
 11 The result is a value greater than or equal to the instrument detection limit but less than the contract required detection limit.
 0 Indicates spike sample recovery is not within control limits.
 1 Indicates a value estimated or not reported due to the presence of interference.
 Q Indicates analytical spike is not within 85-115% control limit for values <0.001 M.
 S Indicates value determined by method of Standard Addition.
 a Samples 901-11 and 908-11 were lost.
 Blank space indicates analysis was not performed on this parameter.
 b Initial analysis was not used because internal standards were not met. Samples were reanalyzed.
 c Sample 908-11 is a duplicate of 905-11.
 0 Data is unusable due to problems with QA/QC in the laboratory.
 0000 Value is reported as not detected because compound was found at concentrations less than five times (ten times for common lab contaminants) the amount in any blank associated with sample.
 F Samples were collected for dissolved metals.

(07/04/12)

07/200

(07/04/11)

Detected volatile organics consist of the following three constituents: acetone detected in MW-902 (12 ug/l) and MW-903 (17 ug/l); methylene chloride which was indicated in sample MW-903, at an estimated concentration of 2 ug/l, and 1,2-dichloroethene indicated at an estimated value of 4 and 1 ug/l in MW-903 and MW-904, respectively. Methylene chloride was probably present as a result of field/lab contamination.

Two base neutrals were indicated in the groundwater wells at estimated concentrations. Bis(2-ethylhexyl) phthalate was detected in MW-902 at 2 ug/l and in MW-903 at 6 ug/l. Fluoranthene was detected in MW-904 at 1 ug/l. Both compounds were indicated at concentrations below AWQC.

Analyses for total metals indicated the presence of nine metals at concentrations ranging from 0.3 - 28,800 ug/l in the groundwater. Zinc (9-2340 ug/l) and chromium (11-541 ug/l) were detected in all the groundwater samples in addition to the field blank. Although detected concentrations of zinc were below groundwater quality standards, three concentrations of chromium (405 ug/L in MW-905, 541 ug/L in MW-906, 71 ug/l in MW-907) exceeded the chromium standard and criteria of 50 ug/l. Lead (2.8 - 756 ug/l) and silver (9 - 22 ug/l) were each detected in six groundwater samples and the duplicate sample. The concentrations of lead in MW-905 (101-109 ug/l), MW-906 (756 ug/l) were above the groundwater standard of 50 ug/l. The detected silver concentrations, however, did not exceed any groundwater standards. Copper (10 - 28,800 ug/l) and nickel (29 - 352 ug/l) were each detected in five groundwater samples including the duplicate sample. The concentration of copper in MW-906 (28,800 ug/l) exceeded NJDEP-GWQS and AWQC of 1000 ug/l. All detected concentrations of nickel exceeded the USEPA - AWQC of 15.4 ug/l. Cadmium and mercury were each indicated in three monitoring wells. Concentrations of cadmium in MW-906 (15 ug/l) and MW-908 (16 ug/l) exceed the cadmium groundwater standard and criteria of 10 ug/l. Only one well (MW-902) contained mercury at a concentration (3.4 ug/l) which slightly exceeds the NJDEP-GWQS and MCL of 2.0 ug/l. Arsenic was only indicated in MW-902 (6.2 ug/l) at a concentration which is greater than the AWQC of .025 ug/l.

Detected dissolved metals (samples are indicated with an F) consist of eight constituents. Cadmium, which was detected in the total metals analysis, was not present. Concentrations of dissolved metals ranged from 0.2 - 142 ug/l. Silver (10 - 24 ug/l) and chromium (9 - 23 ug/l) detected in every groundwater sample, and zinc (12 - 33 ug/l) present in five of the samples were indicated at concentrations below provided groundwater standards and criteria. -Copper (10 - 89 ug/l) was indicated in three samples while mercury (0.2-4.8 ug/l) and nickel (21 - 142 ug/l) were each indicated in two groundwater samples. Detected concentrations of copper were within allowable limits when compared to applicable groundwater quality standards. The mercury level (4.8 ug/l) in MW-902F exceeded the NJDEP-GWQS and MCL of 2 ug/l, while nickel concentrations in both samples exceeded the USEPA-AWQC of 15.4 ug/l. Arsenic was detected in sample MW-902F (4.4 ug/l), and lead was indicated in MW-904F (20 ug/l). The arsenic concentration exceeded its AWQC of 0.025 ug/l.

As shown in Table 3.9-5, analyses for asbestos fibers indicate the following: no asbestos was detected in MW-901 above the detection limit of 50,000 fibers/liter; results for MW-904 through MW-908 were unreadable; and that fibers were indicated in MW-902 (79,809 fibers/liter) and MW-903 (88,210 fibers/liter). Samples MW-902 and MW-903 were collected from the asbestos hill where fibers could have been introduced directly to the water sample as they were extracted from the well.

The third sampling round occurred during the week of October 12-16, 1987. All groundwater samples were analyzed for the same parameters as in the second sampling round. Three laboratories were used to analyze the groundwater samples. Priority Pollutant (PP) volatile organics plus 15 and base neutrals plus 15 analysis were conducted by Radian Corporation of Sacramento, California. Century Laboratories of Thorofare, NJ performed the PP metals (dissolved and total) analyses and Princeton Testing Laboratories performed the asbestos fiber counts. Field tested parameters were presented in Table 3.9-1 and analytical data is provided in Tables 3.9-7 through 3.9-9.

TABLE 3.9-7

SUMMARY OF ORGANIC DATAMILLINGTON SITEGROUNDWATER MONITORING WELL SAMPLES
THIRD ROUND SAMPLING RESULTS*

<u>Volatile Organics (ug/l)</u>	<u>901</u>	<u>902</u>	<u>903</u>	<u>904</u>	<u>905</u>	<u>906</u>	<u>907</u>	<u>908**</u>	<u>FB2-2</u>	<u>TB-4</u>	<u>TB-5</u>
Acetone	67.0	-	17.0	-	-	-	-	-	-	-	-
Benzene	2.6J	50.0	-	-	-	1.2J	-	-	-	-	-
Chlorobenzene	21.0	-	-	-	-	-	-	-	-	-	-
Dichloroethylene	-	-	NDB	-	-	-	-	-	-	1.4J	1.5
Fluorene	-	2.5J	-	-	-	-	-	-	-	-	-
Trans 1,2-dichloroethene	-	-	5.8	-	-	-	-	-	-	-	-
Trichloroethene	-	-	4.9	2.0	2.9	-	-	2.7	-	-	-
Trichlorofluoromethane	-	-	-	0.5J	-	NDB	-	-	-	1.4J	0.9J
Alkenes (total)	9.3	-	-	-	-	-	-	-	-	-	-
<u>Semi-Neutrals (ug/l)</u>											
Bis(2-ethylhexyl)phthalate	17.0	NDB	NDB	NDB	NDB	NDB	NDB	NDB	1.2J	-	-
n-butylphthalate	1.2	1.0J	1.0J	NDB	-	-	-	-	-	-	-
Methylnaphthalene	1.2J	-	-	-	-	-	-	-	-	-	-
Phthalene	2.6	-	-	-	-	-	-	-	-	-	-

With the exception of sample 904 collected on 10/20/87, all samples were collected on 10/19/87.

Field Blank

Trip Blank

) Not Detected

Estimated value less than minimum detection limit

B Value is reported as not detected because it was found at concentrations less than five times (ten times for common lab contaminants) the amount in any blank associated with sample.

Sample 908 is a duplicate of 905.

TABLE 3.9-8

SUMMARY OF PRIORITY POLLUTANT TOTAL METALS DATAMILLINGTON SITEGROUNDWATER MONITORING WELL SAMPLES
THIRD ROUND SAMPLING RESULTS*

<u>Metals (ug/L)</u>	<u>901</u>	<u>902</u>	<u>903</u>	<u>904</u>	<u>905</u>	<u>906</u>	<u>907</u>	<u>908**</u>	<u>FB 2-2</u>
Arsenic	-	[7.0]	-	-	-	-	-	-	-
Cadmium	19.0	-	-	-	-	[4.3]	-	-	-
Chromium	-	[10.0]	17.0	15.0	94.0	268.0	11.0	81.0	-
Copper	[14.0]	[10.0]	[12]	[10]	35.0	10,900.0	[9.0]	31.0	-
Lead	-	-	-	-	23.0 NS	568.0 N	-	21 N	-
Mercury	-	2.6	-	-	4.0	10.0	-	3.2	-
Nickel	[15.0]	-	-	-	71.0	85.0	-	61.0	-
Selenium	2.0	-	-	-	-	-	-	-	-
Zinc	24.0	-	-	-	73.0	1178.0	24.0	75.0	[11]

* With the exception of Sample 904 collected on 10/20/87, these samples were collected on 10/19/87.

* Duplicate of 905

-) Analyzed for but not detected

] Value is greater than or equal to the instrument detection limit but less than the contract required detection limit.

Indicates spike sample recovery is not within control limits.

Indicates value determined by Method of Standard Addition.

B Field Blank

TABLE 3.9-9

SUMMARY OF PRIORITY POLLUTANT DISSOLVED METALS DATAMILLINGTON SITEGROUNDWATER MONITORING WELL SAMPLES
THIRD ROUND SAMPLING RESULTS*

<u>Metals (ug/L)</u>	<u>901</u>	<u>902</u>	<u>903</u>	<u>904</u>	<u>905</u>	<u>906</u>	<u>907</u>	<u>908**</u>	<u>FB 2-2</u>
Chromium	11.0	[5.0]	13.0	15.0	[7.0]	-	[8.0]	[7.0]	-
Copper	[22.0]	26.0	[11.0]	[17.0]	27.0	386.0	[8.0]	[21.0]	[6]
Lead	-	-	-	-	-	12SN	-	-	-
Mercury	-	2.0	-	-	-	0.9	-	-	-
Nickel	[14.0]	-	-	-	[31.0]	-	-	[24.0]	-
Zinc	36.0	38.0	-	-	132.0	158.0	21.0	123.0	[55]

With the exception of sample 904 collected on 10/20/87, these samples were collected on 10/19/87

* Duplicate of 905

..) Analyzed for but not detected

] Value is greater than or equal to the instrument detection limit but less than the contract required detection limit.

Indicates spike sample recovery is not within control limits.

Indicates value determined by Method of Standard Addition.

L Field Blank

Detected volatile organics consist of eight compounds ranging in concentration from 0.5 - 67 ug/l. Trichloroethene was detected in four out of eight samples including the duplicate at concentrations ranging from 2.0-4.9 ug/l. Although concentrations of trichloroethene in MW-903 (4.9 ug/l) and MW-905 (2.9 ug/l) exceeded the AWQC of 2.8 ug/l, they were below the MCL of 5 ug/l. Benzene (1.2-50 ug/l) was indicated in three groundwater samples (MW-901, MW-902, MW-906) at concentrations exceeding the AWQC of 0.67 ug/l, but only the level in MW-902 was above the MCL of 5 ug/l. Acetone, a common laboratory contaminant, was detected in MW-901 (67 ug/l) and MW-903 (17 ug/l). Groundwater standards are not available for this compound. Ethyl benzene (21 ug/l), toluene (2.5 ug/l), trans-1,2-dichloroethene (5.8 ug/l) and total xylenes (9.3) were each indicated in one sample at concentrations below PMCLGs. Toluene and ethyl benzene levels were also below their respective AWQC. No AWQC exist for the other two compounds.

Detected base/neutrals consisted of four compounds which were indicated at concentrations ranging from 1.2-17 ug/l. Di-n-butyl phthalate was indicated in three samples at levels ranging from 1.0-1.2 ug/l which are below the AWQC of 44,000 ug/l. In addition to di-n-butyl phthalate, MW-901, the upgradient bedrock well, contained bis(2-ethylhexyl) phthalate (17 ug/l), naphthalene (2.6 ug/l) and 2-methylnaphthalene (1.2 ug/l). The bis(2-ethylhexyl) phthalate concentration was also below its AWQC. No criteria exist for the other two compounds.

Nine metals ranging in concentration from 2-10,900 ug/l were indicated in the total metals analysis. Copper and chromium were the most frequently detected metals and ranged in concentration from 9-10,900 ug/l and 10-268 ug/l, respectively. The concentrations of chromium in MW-905 (94 ug/l), MW-906 (268 ug/l) and MW-908 (81 ug/l), the duplicate of MW-905, exceed applicable groundwater standards. The concentration of copper in MW-906 (10,900 ug/l) also exceeded the NJDEP-GWQS and AWQC of 1000 ug/l. Zinc (24-1178 ug/l) was indicated in five samples at concentrations below groundwater standards and criteria. Mercury (2.6-10 ug/l) and nickel (15-85 ug/l) were each detected in three groundwater

samples and the duplicate sample. All detected concentrations of mercury exceeded the NJDEP-GWQS and MCL of 2 ug/l, but were at or below the AWQC of 10 ug/l. Concentrations of nickel in sample MW-905 (71 ug/l), MW-906 (85 ug/l) and MW-908 (61 ug/l) exceed the USEPA-AWQC of 15.4 ug/l. Lead was detected at concentrations ranging from 21-568 ug/l in three groundwater samples. The indicated value of this constituent in sample MW-906 (568 ug/l) exceeded the groundwater standard of 50 ug/l. Cadmium (4.3-19 ug/l) was indicated in two samples. The concentration of 19 ug/l in MW-901 exceeded the groundwater standard of 10 ug/l. Arsenic (7 ug/l) and selenium (2 ug/l) were indicated in samples MW-902 and MW-901, respectively. Both values were below MCLs, but the arsenic concentration the exceeded AWQC of 0.025 ug/l.

Detected dissolved metals consisted of six constituents ranging in concentration from 0.9-386 ug/l. Chromium (5-15 ug/l) and copper (6-386 ug/l), the most frequently detected metals, were indicated in seven and eight samples, respectively, at concentrations below applicable standards and criteria. Nickel was indicated in three samples at estimated levels ranging from 14-31 ug/l. Concentrations of this constituent in sample MW-905 (31 ug/l) and MW-908 (24 ug/l) exceeded the USEPA-AWQC. The remaining detected metals consist of lead (12 ug/l) indicated in MW-906, mercury (0.9-2 ug/l) indicated in MW-902 and MW-906, and zinc (21-158 ug/l) indicated in six samples. The levels of these three constituents are within allowable limits when compared to groundwater quality standards.

Asbestos fiber analysis indicated that only two samples contained asbestos above detection limits (Table 3.9-5). MW-902 indicated 58,800 fibers/liter and 142,000 fiber/liter were detected in sample MW-903. It should be noted that these samples were collected from wells which are screened within the asbestos fill deposit. Asbestos fibers are probably drawn directly from the fill into the water samples during sample collection. It should also be noted that detection limits varied from sample to sample due to high content of particular matter causing interference during analysis.

3.10 Aquatic Biota Sampling

3.10.1 Purpose. This phase of the study was undertaken to determine if the disposal of asbestos-containing wastes or other contaminants, if any, at the Millington Site had any noticeable effect upon the biological communities in the downstream rivers and creeks. This study is an evaluation of the quality of the aquatic ecosystem and was performed as part of a regional investigation which included the tributaries to the Passaic River in the vicinity of the satellite sites. Only the stations near the Millington Site are discussed in this report.

3.10.2 Methodology. It is never easy to scientifically interpret ecological quality, because the criteria may differ widely between different ecosystems or even different observers. There are, however, two general criteria that can be applied almost universally. These are:

- A. Species diversity. A fundamental rule of ecology is that a well-balanced ecosystem has a diversity of species, whereas a stressed ecosystem has but a few species due to the restriction of niches. There is no direct correlation between number of species and the well-being of an ecosystem. The numerical abundance of each species, and proportion and types of species showing dominance must also be factored in. The validity of this method lies in comparing a stressed ecosystem with an analogous system which is known to be unstressed (i.e., control).

The method requires the use of experience and judgment to distinguish diversity among divergent or related species. There have been several mathematical treatments suggested to develop a more objective approach to a "Species Diversity Index," but none seem to offer any definitive substitution of the skill and judgment of the trained observer.

- B. Indicator species. Through empirical observation, certain species have been correlated with the quality of an ecosystem.

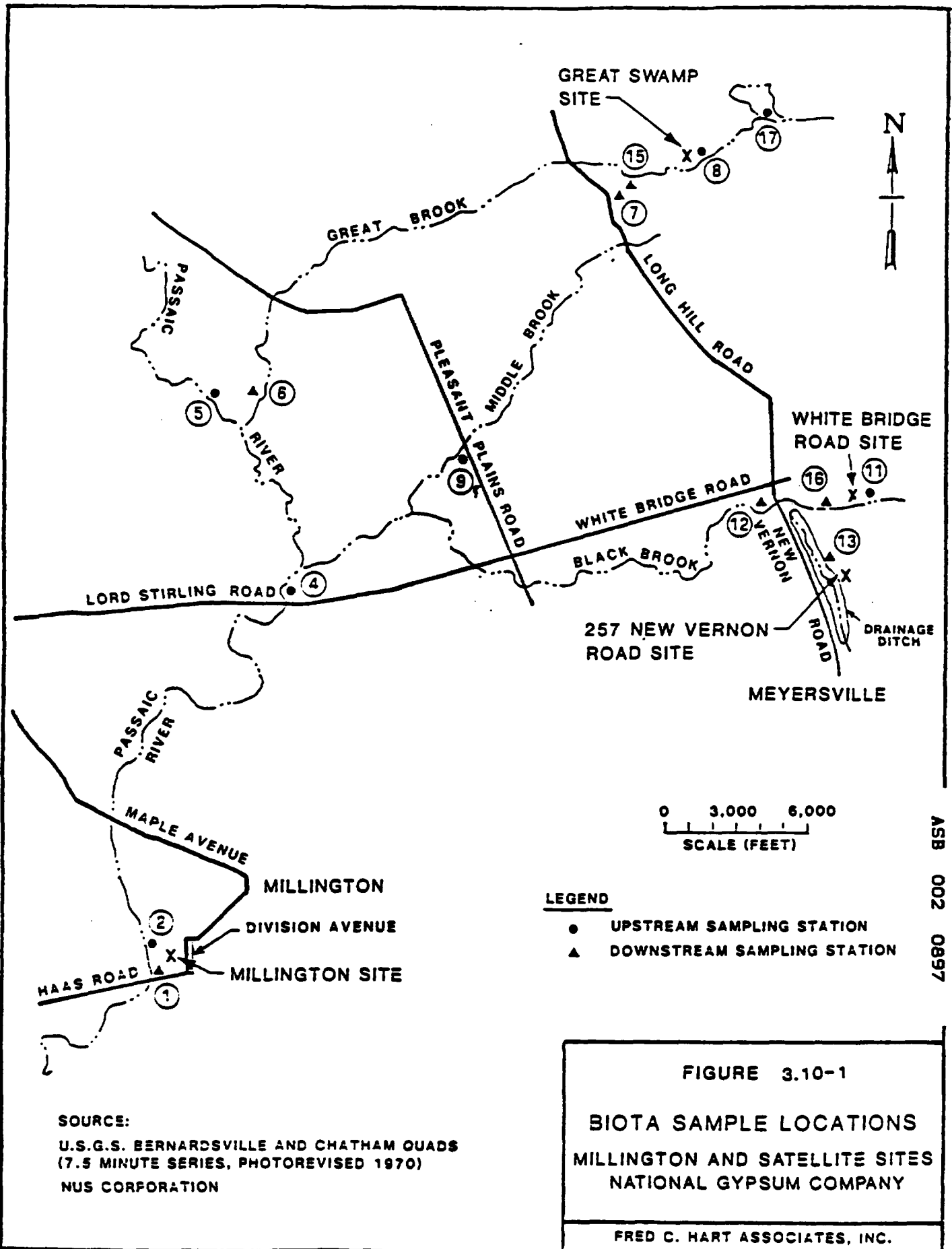
The evaluation is somewhat subjective, also, as good statistical data is lacking which specifically relates species to chemical parameters.

In order to describe, assess and compare the two stations (Stations 1 and 2) in this part of the project, the following steps were undertaken:

- The variety of habitats and communities were observed at each station during a field inspection. Figure 3.10-1 provides all the stations investigated in the regional study.
- Samples were collected at each station, including specimens from the assorted communities and habitats
- Each sample was entirely examined, macroscopically and/or microscopically and organisms sorted from the background sediment, detritus, etc.
- Each specimen was identified through Phylum, Class and down to the genus and species level when possible
- Specimens were individually counted where practical or a subjective comparative value was designated

Representatives from the following habitats and community types were recovered from the stations:

- benthic organisms, both macrofauna and the smaller meiofauna, those animals that live on or in the bottom sediments were recovered by sieving the sample through a series of graded size sieves, stained with rose bengal and preserved with 10% formalin.
- aquatic plants, the large macrophytes, including submerged, emergent and floating types and the mats of the macroscopic algae were collected and preserved.



- the microscopic epi- or periphyton/aufwachs, attached organisms living on or in association with the preceding group, were flushed and rinsed from the macrophytes and preserved.
- the drifting, floating microscopic plants and animals of the water column which are the phytoplankton and the zooplankton were collected by a dip sample, preserved, settled, decanted and, in some cases, centrifuged to concentrate for examination.
- plants and animals attached to pebbles, larger rocks, leaves, submerged decaying logs, floating mats and twigs, etc.
- neuston, those species inhabiting the interface between air and water at the river's surface, were collected with a net sweep and preserved.

To facilitate comparisons and interpretation, all species from the above communities were regrouped into four major natural types:

- phytoplankton-microplants
- zooplankton-microanimals
- aquatic plants-macroplants
- animals-macroanimals

3.10.3 Findings. As discussed below, both stations exhibited some representatives from each of these four groups. Neither station was dramatically devoid of species from any community type. Appendix H is a list of all species found at each site.

3.10.3.1 Indicator Species and Species Diversity for all stations.

Plankton. The total plankton community (phyto- and zoo-) was, well-represented at station #1 and not well represented at Station #2 with the total number of species at each being 42 and 21 respectively (Appendix H). Station #1 had a good assortment of phytoplankton, the

plant fraction, with station #2 supporting very few species. The animal fraction, or zooplankton, at each station was 6 and 3 respectively.

Phytoplankton. In a healthy, unstressed water column, the phytoplankton is typically composed of a variety of types of microscopic plants: diatoms, desmids, dinoflagellated, other assorted motile and non-motile species and probably a few blue-greens. No dinoflagellates were observed in these stations; however, station #1 exhibited representatives from all of the other groups. Station 2 only exhibited diatoms and a few of the others such as the blue green. Desmids, which usually occur in unstressed "clean" waters, were observed at Station #1 which is directly downstream of the Millington Site. Diatoms, which usually prefer water with some enrichment, were well-represented, with at least 13 species being observed at station #1, and ten being observed at station #2.

Both stations also had at least one species of the ubiquitous flagellated green algal species, Euglena and Phacus. Euglena prefers still, stagnant water, Phacus does not, and both species were recorded in bloom abundance. Station #1 supported one species of Euglena, and one species of Phacus while station #2 had two species of each. A related taxa, the genus Trachelomonas, which grows abundantly in iron-enriched waters, is often responsible for orange or rusty discolored water when it blooms in great abundance. Five species were observed at station #1, and station #2 exhibited at least one representative. The presence of blue-greens, or Cyanobacteria, is usually indicative of enhanced nutrient enrichment. While blue greens were present at both stations, station #1 had three species and station #2 had one species.

Zooplankton. The zooplankton fraction of the plankton community is typically composed of representatives from a number of different animal invertebrate phyla, and again high diversity is usually an index of "health" or lack of stress to the site. Six phyla, including the one-celled Protozoa, the Rotifera, the Arthropoda and three worm groups, the flatworm, the roundworm and the segmented worm (Platyhelminthes

Nematoda and Annelida, respectively) were recorded at station #1. Station #2 had all Phyla present except Rotifera.

Aquatic Plants. Three species of macroscopic plants, including vascular plants and algal mats, were recovered from the banks, stream beds and near-shore littoral zones of both stations. Both stations had dense stands of plants with station #1 having the water surface almost covered by plants.

Animals. The invertebrate animals exhibited the second greatest diversity of the four major groupings, with a total of 19 different species, representing three phyla in station #1 and 10 species representing four phyla in station #2.

3.10.3.2 Site-Specific Appraisals.

In order to get a better picture of the healthiness of sites 1 and 2, it is best to look at these two stations as compared to the total biota survey which was done for the Passaic River and its tributaries in the vicinity of the four asbestos disposal sites (14 sampling locations).

Stations 1 and 2. The upstream Millington Site station, #2, with only 36 total species, ranked lowest in species diversity for the entire series (Table 3.10-1). However, this site also had the highest stream velocity and the sandy, pebbly bottom is indicative of extensive water movement. The low species diversity exhibited at this site for the plankton community is to be expected under these physical parameters. The animals, however, were fairly-well represented and ranked in mid-range.

At station #1 located downstream of the Millington Site, there is also a current; however the abundance of one species of submerged aquatic plant has created a habitat, which supports a much greater total diversity (62 species), placing this station in the mid-range for the series. Station in the mid-range for the series. Considering the physical parameters (Table 3.10-2) at this site, this station appears healthy.

TABLE 3.10-1
SITE-SPECIFIC SPECIES RANKING FOR THE REGIONAL STUDY AREA

<u>Rank</u>	<u>Total # Species</u>	<u>Station #</u>
1	88	7
2	79	15
3	78	9
4	76	12
5	75	4
6	69	17
7	67	6
8	63	11
9	62	1
10	56	5
11	49	16
12	44	13
13	44	8
14	36	2

TABLE 3.10-2

PHYSICAL CHARACTERISTICS OF THE BIOLOGICAL STATIONSMILLINGTON SITE

<u>Station</u>	<u>Location</u>	<u>Stream Velocity at Surface (ft/sec.)</u>	<u>Maximum Stream Depth (inches)</u>	<u>Bottom Sediment and Cover (type)</u>	<u>Type and Amount of Vegetation</u>	<u>General Description</u>
1	D	1.61	11	Silty, little to no detritus	70% attached grass in center with some duckweed and algae present	Open river, flowing water, wide
2	B	1.92	14	Sandy to pebbly in center; silty in stillwater areas; brown diatomaceous film on bottom.	No submergent or emergent vegeta- tion	Open river, flowing water (at bend), wide

D - Downstream

B - Background

4.0 GEOLOGY AND HYDROGEOLOGY

4.1 Introduction

In order to assess the potential for contaminant migration from the Millington Site, it is necessary to understand the site-specific geology and hydrogeology of the investigated area. The previous chapter described the range of field investigative and laboratory analyses performed by HART and their subcontractors as part of the Site Operations Plan. The information obtained from that work provides the basis for the following discussions of regional and site geology and hydrogeology.

4.2 Geology

4.2.1 Regional Geology. The Millington Site is located within the north-central area of the Piedmont Physiographic Province. This province is made up of the Newark Supergroup deposits of the Newark Basin, which is one of many Newark Supergroup basins that parallel the Appalachians along the east coast of North America. The Newark basin covers 7,770 square kilometers and stretches 220 kilometers along its long axis and contains the thickest sedimentary sequence of any exposed Newark Supergroup Basin. Deposits of the Newark Basin consist of predominantly red clastics (sandstones, siltstones and shales) and volumetrically minor basaltic igneous rocks, (Olsen, 1980). These deposits are divided into nine formations (called from the bottom up): Stockton Formation (maximum 1,800 meters); Lockatong Formation (maximum 1,150 meters); Passaic Formation, formerly the Brunswick Formation (maximum 6,000 meters); Orange Mountain Basalt, formerly the First Watchung Basalt (maximum 200 meters); Feltville formation, formerly the Brunswick Formation, (maximum 600 meters) Preakness Basalt, formerly the Second Watchung Basalt (maximum 300 meters); Towaco Formation, formerly the Brunswick Formation (maximum 340 meters); Hook Mountain Basalt, formerly the Third Watchung Basalt (maximum 110 meters); and the Boonton Formation (+500 meters).

The Newark Basin formed in association with late Triassic rifting and the opening of the Atlantic Ocean. Prior to the separation of North

America from north Africa and western Europe, basin subsidence had already occurred and slight basin deposition was initiated. As full scale rifting progressed, Newark Basin subsidence and its associated deposition increased. The resultant sedimentary sequence and igneous activity (previously described) continued from the early Late Triassic through the middle Early Jurassic.

The rocks of the Newark Basin uncomfortably overlie (or intrude) Pre-Cambrian and Paleozoic rocks, (Olsen, 1980). They are, in turn, overlain by Post-Jurassic rocks of the Coastal Plain, Pleistocene deposits or Recent alluvium and soils (Olsen, 1980).

Pleistocene deposits overlie the Newark Basin deposits in the field study area. These deposits consist of glacial drift and glacio-lacustrine sediments that were deposited during the Wisconsin Glaciation.

The glacial drift deposits consist of moraine and fluvial-glacial sediments. A moraine traverses the vicinity of the study area in a northeast-southwest direction just north of the Great Swamp National Wildlife Refuge. This moraine is breached at two locations, one north of Morristown and the other in Chatham Borough and Summit Township. South of the terminal Moraine lie the fluvial-glacial outwash deposits. These deposits were laid down following the maximum advancement of the ice front after the ice began to recede to the north. These outwash deposits are on the order of 100 feet along the Passaic River (Fischer, 1980).

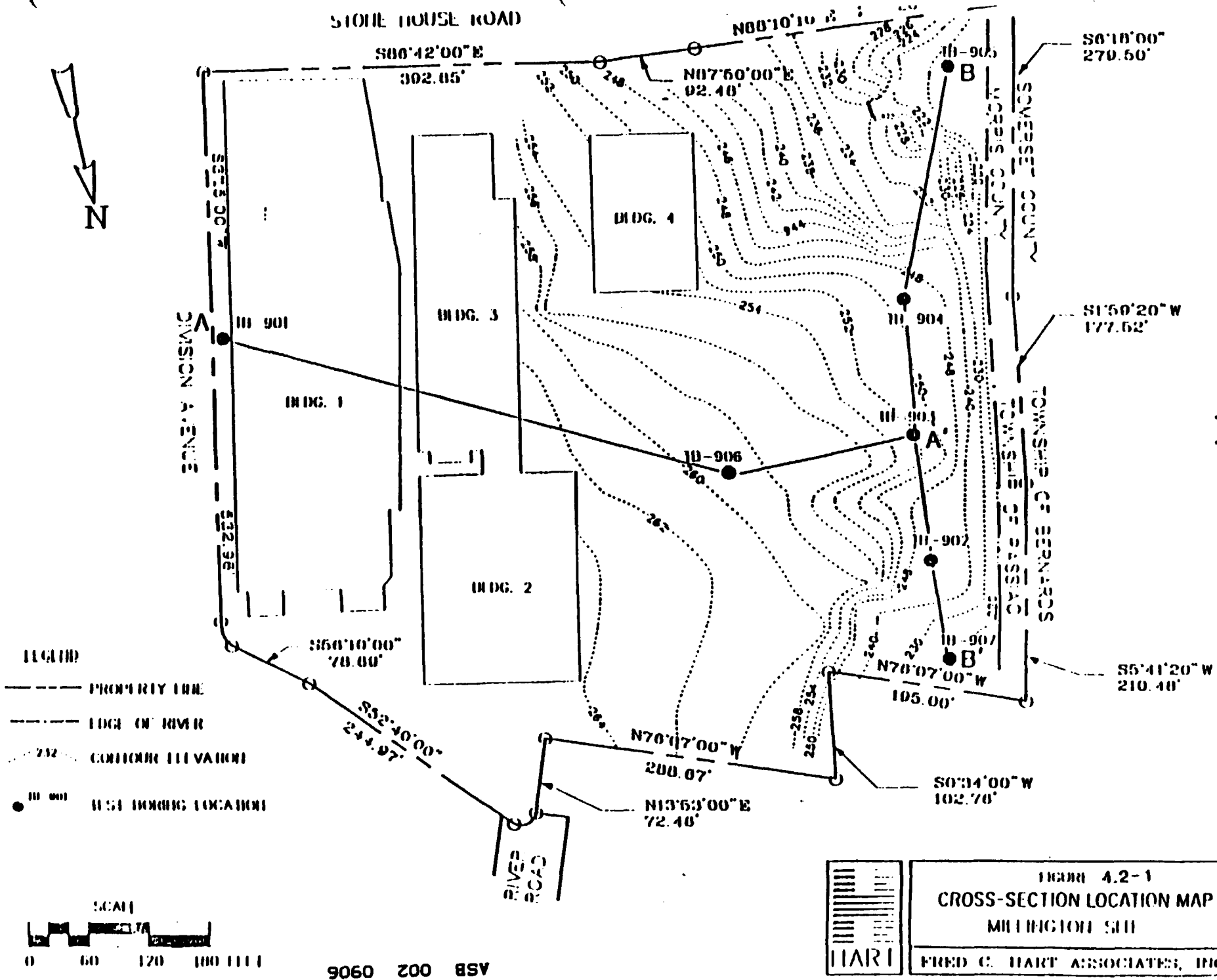
Glacial lacustrine deposits are very extensive in this part of the Newark Basin. They consist of relatively impermeable silts and clays that were deposited within the former proglacial lake, Glacial Lake Passaic. This lake formed as ice melted during glacial retreat following the emplacement of the terminal moraine that had closed gaps in local topography and hence, acted as a dam. At its greatest extent, Glacial Lake Passaic was about 30 miles long, 8 to 10 miles wide and 160 to 200 feet deep. When the retreating ice uncovered a gap to the north, the lake

drained. The Great Swamp and other nearby marshlands are remnants of this glacial lake (Vecchioli, et al., 1962).

4.2.2 Site Geology. The Millington Site is located between the Second and Third Watchung Basalts (Preakness and Hook Mountain, respectively). The bedrock geology in this area consists of coarse-grained siltstone of the Towaco formation. The overall geology at this site (Figure 4.2-1 and 4.2-3) consists of fill that is situated on a silt/clay deposit that directly overlies bedrock. Bedrock is shallowest at the eastern section of the site at TB-901 (Figure 4.2-2) where it is encountered at approximately four and one-half feet below ground surface. The bedrock slopes westward toward the Passaic River where it lies approximately 32 feet below the asbestos mound.

The overlying fill deposit consists of yellow, medium-grained sand in the vicinity of TB-901 and reddish-brown silty to clayey topsoil fill, with a slight veneer of asbestos waste products (broken tiles, shingles and siding) at the surface, throughout the remainder of the site. This unit ranges from one-half foot thick at TB-901 and increases in mass to six feet at TB-906 and is only two feet thick at TB-903. Below this upper fill deposit is a deposit consisting solely of loose asbestos fiber. The asbestos waste layer was observed at TB-906 where nine feet was encountered and on the asbestos waste mound at TB-903. Underlying the asbestos waste is the silt-clay unit which is observed throughout the site. This unit fluctuates from four and one-half feet thick at TB-901 to just under one foot at TB-906 and decreases in thickness to four feet at TB-903. Below this unit lies the siltstone bedrock. Figure 4.2-3 represents the overall subsurface extent of asbestos waste fill as assessed from aerial photo interpretation and test boring information.

Cross-section B-B' (Figure 4.2-3) shows the site geology along the western portion of the Millington Site and specifically details the structure of the asbestos mound. Elevation of the mound ranges from 253 in the center to 250 feet along the flanks. Basically, the geology of the mound consists of 4 units. The uppermost unit consists of a veneer of silty to clayey soil fill approximately 6 to 8 inches deep. Beneath the



ASB 002 8SV 9060

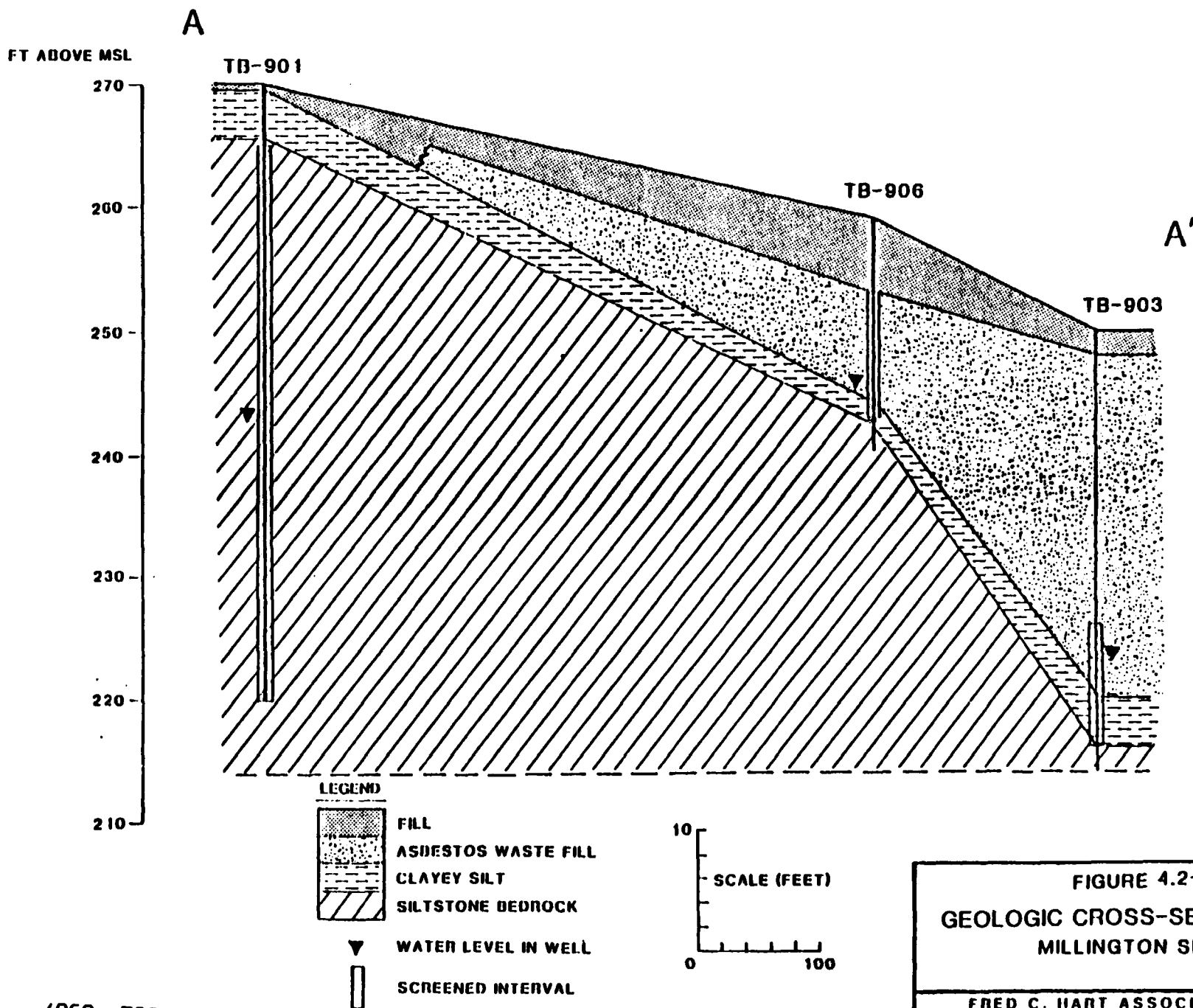
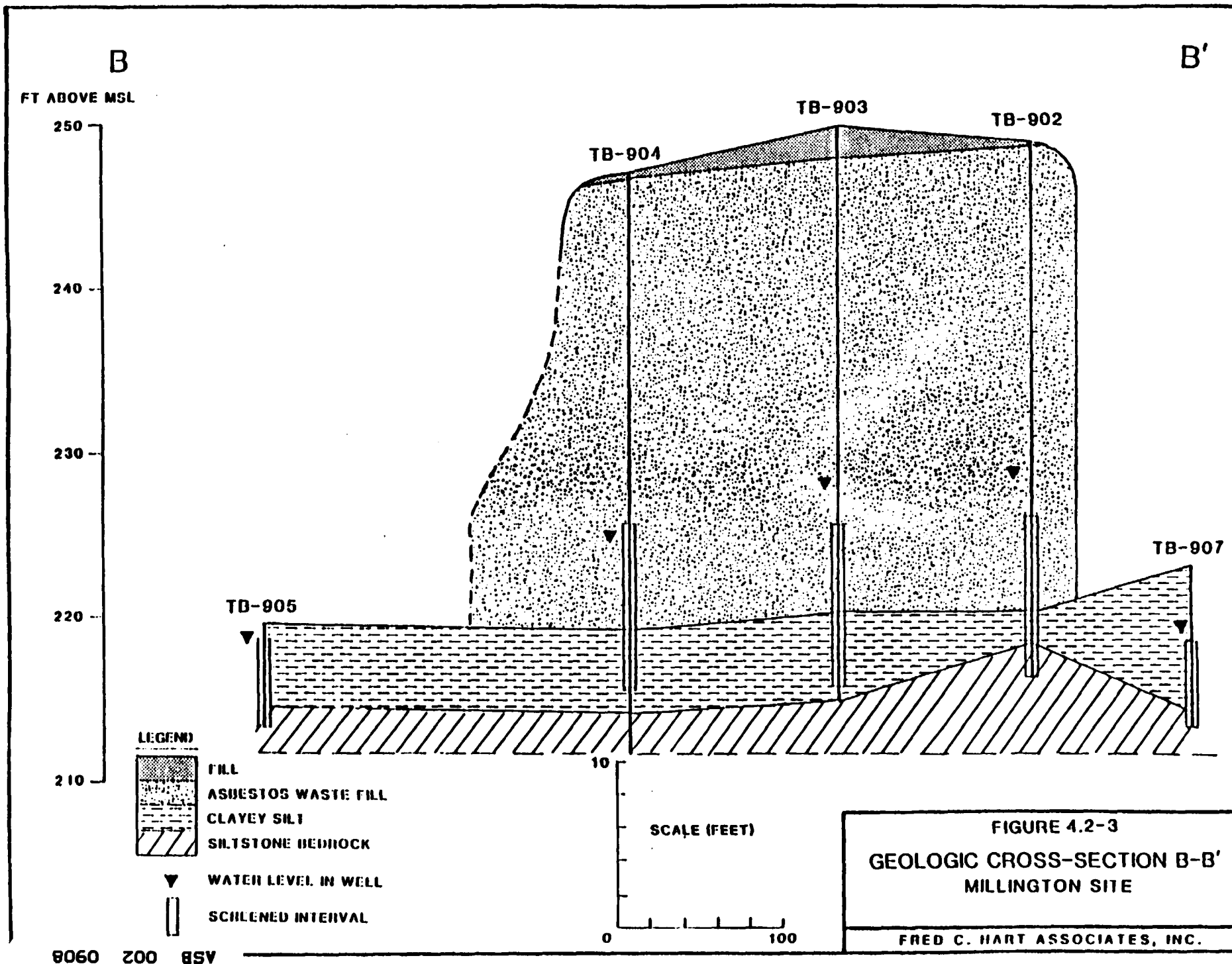


FIGURE 4.2-2
GEOLOGIC CROSS-SECTION A-A
MILLINGTON SITE

FRED C. HART ASSOCIATES, INC.

4060 200 BSV

4-5



fill layer lies the asbestos deposit. This deposit is the most massive unit and is responsible for the existence of the asbestos mound. The asbestos deposit consists solely of pure, loose, asbestos fiber. Although fibers colored green, yellow, and pink were occasionally encountered, the fibers for the most part were white-colored. The unit ranged from 28 feet thick in the middle to 24 feet thick toward the edges. The following underlying unit was made up of a coarse-textured, reddish-brown silty-clay to clayey silt. This layer averages only between 4 to 7 feet in thickness and probably formed by the weathering of the underlying bedrock unit. The siltstone bedrock is shallowest in the vicinity of the river. The upper four to six feet of this unit is extremely weathered which has helped make it a water-bearing zone. The exact thickness of the bedrock at the site is not known but has been reported to be up to 340 meters in this vicinity.

4.3 Hydrology

4.3.1 Surface Water. The Passaic River in the vicinity of Millington, NJ has a drainage area of approximately 55.4 square miles. The ultimate source of water in the Passaic River and its tributaries is precipitation (Anderson and Faust, 1973). Not all precipitation becomes streamflow because of evapotranspiration. The estimated waterloss in the Passaic River Basin in the headwaters near Millington is 25-26 inches per year (Anderson and Faust, 1973).

The Passaic River is classified as an FW2 non-trout surface water. This designation signifies that the surface water body is not designated as FW1 or Pinelands Water. The following lists the designated uses of all FW2 waters:

- Maintenance, migration and propagation of the natural and established biota;
- Primary and secondary contact recreation;
- Industrial and agricultural water supply;

- Public potable water supply after such treatment as required by law or regulation; and
- Any other reasonable uses.

Primary contact recreation is defined as recreational activities that involve significant ingestion risks and includes but is not limited to, wading, swimming, diving, surfing and water skiing. Secondary contact recreation means recreational activities where the probability of water ingestion is minimal and includes, but is not limited to, boating and fishing.

The direction of stream flow at the Millington Site is north-south. Streamflow data indicate that precipitation is the controlling factor on waterflow quantity and flow velocity. Periods of low precipitation (usually during the Summer) are characterized by low flow rates and discharge of water volume. High precipitation experienced during the Fall and Spring results in an increase in both the flow volume and rate. The average flow rate of the Passaic River near the Millington Site is 83.6 cubic feet per second (cfs).

Data on the regional surface water quality of that part of the Passaic River near the Millington Site is limited to the concentration of ions and trace elements. The Millington Site is located within the Piedmont Lowland part of the Passaic River Basin characterized by a dissolved solids content ranging between 100-400 mg/l. The predominant cations are the alkaline earths ranging from 40-70 percent. Consequently, the percentages (30-60) of alkali metals in the region are the highest observed in the basin. The predominate anions in this region are those associated with salinity, principally sulfate and chloride but also nitrate and minor amounts of fluoride.

Biochemical data is available for dissolved oxygen (DO) and biological oxygen demand (BOD). Observations of dissolved oxygen at Millington within a ten year period (1961-1971) indicate a downward trend with an

ASB 002 0910

average percent DO saturation of 65. During the same period of study the average BOD was estimated to be 2.3 mg/l.

4.3.2 Flood Potential. The western-most sector of the Millington Site lies within the flood plain of the Passaic River. Of special concern is the asbestos waste mound which is situated directly on the flood plain and rising approximately thirty feet above the Passaic River. Conversations with residents along the Passaic River adjacent to the Millington Site, reveal that local, annual flooding occurs one to three times per year. The flooding generally occurs during the Spring with the flood waters extending up to fifty feet over the river banks. During hurricane activity the floodwaters have been observed to extend up to eighty-five feet over the river bank.

4.3.3 Drainage Patterns. Drainage at the Millington Site is a relatively simple process consisting of direct surface runoff or transport via groundwater or a storm sewer network. Surface runoff is controlled by topography of the site. The overall topography slopes east-west towards the Passaic River. It is expected that rainwater would runoff as overland flow towards the Passaic River after the soils reach their saturation point and rainwater cease infiltrating into the ground. Surface runoff also occurs on the asbestos mound and a slightly pronounced network of rills has been established on the slope facing the Passaic River. Rainwater that percolates through the soil can become entrained within the storm sewer located within the empty back lot area. Rainwater percolating through the site will become entrained in the local groundwater flow direction which is towards the Passaic River, located just west of the site. The ultimate discharge of all surface and subsurface drainage is the Passaic River.

4.4 Hydrogeology

4.4.1 Regional Hydrogeology. The Millington Site lies within the central basin region of the Passaic River drainage basin. The Passaic River basin drains an area of 935 square miles of which 785 square miles

are in New Jersey and 150 square miles are in New York (Anderson and Faust, 1973).

The central basin is a broad, flat, oval-shaped area that includes a little more than one-quarter of the Passaic River basin. Freshwater swamps or marshes occupy about 14 percent of the central basin area. The Great Swamp is the largest of these wetland areas.

The Quaternary deposits that overlie the bedrock are the most extensive aquifers in Morris County. These deposits consist of clay, silt, sand, gravel and boulders, and fall into three general classes: terminal moraine, ground moraine, and stratified drift. Of the three, it is the stratified drift deposits that are important in terms of groundwater (Gill et al., 1965).

The stratified drift deposits consist of two hydrologic units, an overlying unconfined and a confined unit, that are separated by a massive confining unit. Unconfined groundwater occurs in the stratified drift deposits where they are not mantled by glacial till. These drift deposits are related and closely associated with the present-day alignment of the surface-drainage network. The unconfined aquifer is recharged directly from precipitation on the outcrop area of the stratified drift.

Beneath the unconfined unit lies the confining unit. This unit is composed of varved silt and clay and range in thickness from less than five feet to more than 80 feet (Vecchioli et al., 1962). In the Great Swamp, the average thickness is about 60 feet (Miller, 1965). The confining silts and clays are not completely impermeable and groundwater from the underlying aquifer is able to move upward through the confining materials in response to hydrostatic pressure gradients and discharge into the swamps. The average permeability of the confining materials is estimated to be about 0.002 gpd per square foot (Vecchioli et al., 1962).

Underlying the confining unit is the confined stratified drift aquifer. This aquifer is primarily composed of sands and gravels. This

aquifer lies directly on the bedrock. These confined drift deposits are concealed and their regional extent is not as apparent as the unconfined drift. The confined aquifer is recharged in part from the underlying and adjacent bedrock. Water entering fractures in the bedrock is derived from precipitation in the upland outcrop areas. This water moves under artesian pressure in response to the hydraulic gradient through the fractures. Analyses of the piezometric surface for this aquifer shows a regional slope to the southeast indicating the general direction of the groundwater movement.

As a whole, the lower Quaternary deposits are the most productive aquifers in Morris County. The average coefficient of transmissibility of the aquifers is estimated to be about 135,000 gpd per foot, and the coefficient of the storage is estimated at 3.9×10^{-4} (Gill et al., 1965).

The shale and sandstone beds of the Triassic age bedrock underlie the southeastern third of the county where, for much of this area, they are the only source of groundwater. The shale and sandstone beds are generally capable of sustaining moderate to large yields, whereas the basalt is capable of yielding only small supplies.

Unconfined groundwater occurs in the bedrock in their upland outcrop areas. In lowland areas, the rocks are mantled by unconsolidated Quaternary deposits that, in most places, contain one or more clay beds. The clay beds act as confining layers to the groundwater in the underlying rocks; hence, it is under artesian pressure. In the lowest-lying areas, the artesian head is commonly above land surface resulting in flowing wells. Locally, artesian conditions result from differences in hydraulic conductivities within the rock layers that are due to varying degrees of fracturing, weathering or a combination of both.

The storage and movement of groundwater in the bedrock take place largely in numerous fractures that intersect the rocks. Additional void space is provided in the sandstone beds where cementing material is

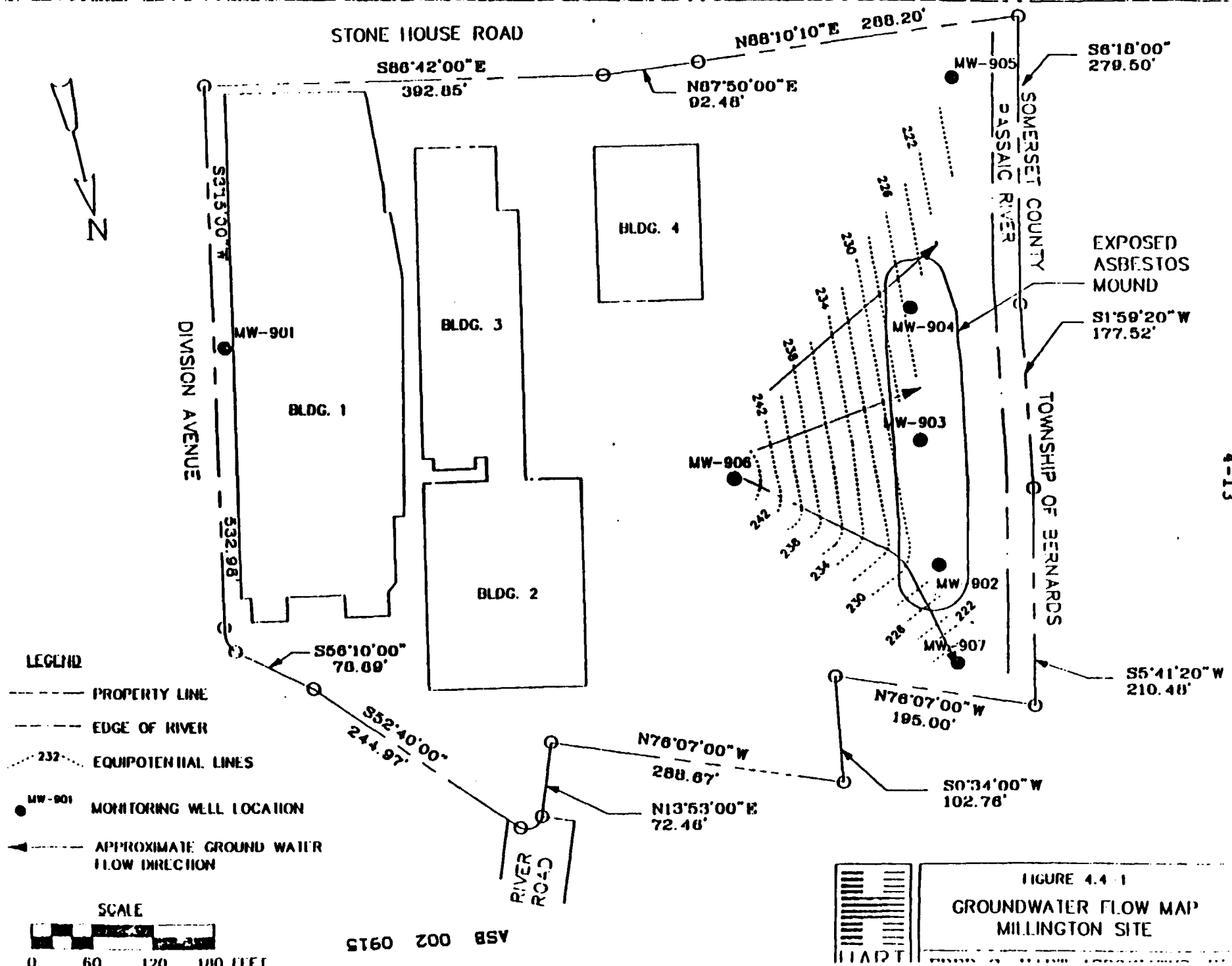
lacking. Vesicles in the basalt add to the porosity resulting from the fractures. However, all these openings constitute only a very small part of the volume of the bedrock and their capacity to store and transmit water is limited.

The coefficients of transmissivity, determined from pump tests, range from 7,500 to 30,000 gpd per foot; most of the values lie between 20,000 to 30,000 gpd per foot. The average coefficient of storage is estimated at 0.0005 (Gill et al., 1965).

Water is available from the bedrock at different zones. In areas where rocks are exposed at the surface, the shallowest zone contains unconfined water which probably extends downward to about 200 feet. The greatest degree of fracturing occurs within this zone, but the rock is highly weathered and the products tend to fill in the fractures, decreasing its permeability. At depths between 200 and 500 feet, one or more artesian zones of greater permeability and, hence, water yield, are reached. Beyond 500 feet, the fractures are fewer and the water yield presumably lower.

4.4.2 Site-Specific Hydrogeology. The uppermost aquifer at the Millington Site is found within the unconsolidated silty-clay/clayey silt unit that lies directly over bedrock. This unit is found at a depth ranging from 1 to 30 feet below the surface (Figure 4.2-2). The thickness of this unit ranges from one to four and one-half feet across the site. Along the river, the thickness is slightly greater, ranging from 3.6 to 6.0 feet.

Groundwater elevations for 11-29-86 were plotted and contoured to assess groundwater flow paths at the site (Figure 4.4-1). The potentiometric surface map indicates that groundwater is flowing in an east-west direction toward the Passaic River under the influence of bedrock topography. The groundwater flow gradient is 0.047 and was calculated from the change in head between the monitoring wells over the distance in which the change occurred (dH/L). Essentially, the gradient indicates that for every 100 feet of land surface, the water table drops four feet.



Hydraulic conductivity values assessed from slug test measurements in the silt/clay unit range from 2.8 to 4.02 feet per day. The average of these values (3.23 ft/day) was utilized in determining the rate of ground- water flow velocities (Table 4.4-1). The apparent velocity (or specific discharge) of the silt/clay unit was determined by multiplying the value of the average hydraulic conductivity (K) with the value of the average hydraulic gradient ($dH/L=i$). An apparent velocity of 55.7 feet per year (ft/yr) was calculated for the unit. The real velocity (or seepage velocity), which reflects the true rate of groundwater flow, was then calculated by dividing the apparent velocity by the effective porosity. The effective porosity of the silt/clay unit was estimated at a range of 30-33 percent. The seepage velocity is always greater than the apparent velocity. The seepage velocity ranged from 168.8 to 185.7 ft/yr.

TABLE 4.4-1
HYDROLOGIC PARAMETERS

<u>Site</u>	<u>Average Hydraulic Conductivity ft/day</u>	<u>Average Hydraulic Gradient</u>	<u>Discharge Velocity ft/yr</u>	<u>Seepage Velocity ft/yr</u>
Millington Site	3.23	0.047	55.7	168.8-185.7

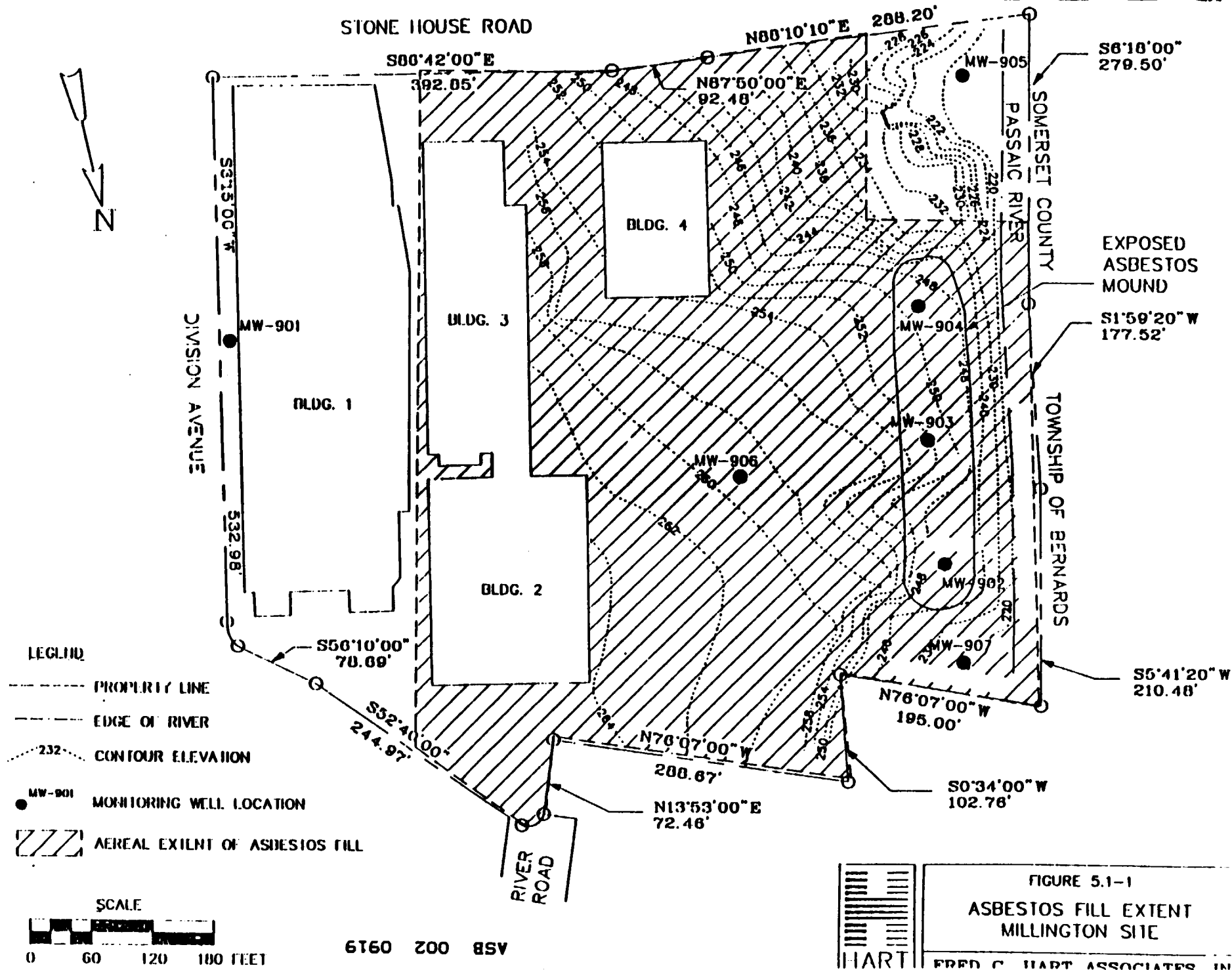
5.0 EXTENT OF CONTAMINATION

5.1 Millington Site

5.1.1 Asbestos Waste. The Millington Site contains a large volume of landfilled asbestos waste products. These asbestos waste products are present within the Millington Site as either part of an asbestos waste mound or subsurface asbestos fill deposit. The asbestos waste mound is located in the western sector of the site along the Passaic River. It is composed solely of loose asbestos fibers and is approximately 330 feet long, 75 feet wide and 26-30 feet thick. The subsurface asbestos fill deposit is present throughout the site and consists of broken asbestos tiles and siding that is intermixed with asbestos fibers. This deposit lies at the surface of the site and is 7 to 14 feet thick.

Data supplied from test borings and aerial photographs was used to construct a map, Figure 5.1-1, illustrating the extent of asbestos material at the site. Figure 5.1-1 shows that over 90 percent of the site contains asbestos waste products. Only the immediate area in the vicinity of the main plant building and in the southern sector of the property are free of asbestos waste.

Two forms of containment exist for the asbestos waste located within the site. First, at the asbestos waste mound, there exists a clayey topsoil fill deposit and an extensive mixed vegetative cover which act in concert to reduce the release of asbestos fibers. The clayey topsoil fill deposit ranges from a few inches to two feet in thickness throughout the surface of the asbestos mound and lies directly above the unit of loose asbestos fibers. Vegetative cover composed of a variety of trees, grasses, vines and bushes is present throughout the surface, slope and base of the asbestos mound. In addition to containing the asbestos waste, this vegetative assemblage acts to strengthen the stability of the mound.



The two forms of containment previously discussed are also present on the remainder of the site, particularly on the field located east of the asbestos mound. This area contains surficial and subsurface asbestos waste products. The clayey topsoil fill deposit found at TB 906 is six feet thick and lies directly above a unit of loose asbestos fibers. Some asbestos waste products in the form of broken chips and siding are intermixed in this topsoil unit. The topsoil is covered with grasses and shrubs which act to contain the surficial asbestos waste products. The environmental release of asbestos fibers from the subsurface is also controlled by the topsoil and vegetative covering.

Based on the limited available data, it is conservatively estimated that there is approximately 942,186 cubic feet of asbestos and asbestos fill material at the Millington Site. This is assuming that there is an average of six inches of surficial asbestos material covering the site from just east of Buildings 2 and 3, west to the Passaic River and that the asbestos mound is 330 feet by 90 feet by 33.5 feet deep. This estimation does not include an area 180 feet by 157 feet in the northwestern corner of the property around TB-905.

5.1.2 Surface/Subsurface Soils. A complete evaluation of the type and extent of chemical contamination of the soils (including the asbestos waste deposits) is available since all test boring samples selected for laboratory analysis underwent full Priority Pollutant plus forty analysis. Test boring samples were recovered from the following three types of material: silty-clay topsoil, asbestos waste deposits and soil from the underlying silt/clay unit that, in some cases, are characterized by the presence or lack of certain contaminants.

Contaminants detected within the asbestos mound consisted of metals and volatile organics along with phenols, cyanide and one pesticide. Six metals were detected at concentrations ranging from 0.39-301 mg/kg, of which only one, mercury, was present at concentrations above normal range in natural soils. Mercury was present in four of five soil samples in two

test borings from this deposit at concentrations ranging from 0.39-6.6 mg/kg.

Volatile organic compounds encompass the second largest group of contaminants within the asbestos mound. A total of seven volatile organics were detected ranging in concentration from 1-110 ug/kg. Of the detected volatile organics, methylene chloride and toluene were present in the highest concentrations. Because these two compounds are common laboratory contaminants and were also detected in the method blank sample, their presence may not be indicative of soil contamination. The remaining volatile organic compounds (trichlorofluoromethane, chloroform, benzene, acrylonitrile, and trichloroethene) were present in only some of the samples from this unit at relatively lower concentrations ranging from 0.4-80 ug/kg. The first three compounds were also detected in method blank samples.

The only other contaminants found in the asbestos mound consist of phenols (5.3 mg/kg), 4,4-DDE (5.2 ug/kg) and cyanide (0.1 mg/kg). Phenols and 4,4-DDE were detected in only one sample each and cyanide was detected in two samples from the asbestos mound.

Contamination in the subsurface asbestos deposit is limited to metals and several volatile organic compounds. Six metals were present in the subsurface waste deposit and have concentrations ranging from 0.42-309 mg/kg. Only mercury, which was present in three soil samples, detected at concentrations (0.42-7.8 mg/kg) above common levels for natural soil deposits. The volatile organics are the largest group of contaminants detected in this deposit. As in the asbestos mound deposit, methylene chloride and toluene are detected at the highest concentrations (30-150 ug/kg) and were present in every sample from this unit. The remaining compounds (trichlorofluoromethane, chloroform, 1,1-trichloroethane, trichloroethene, benzene and ethyl benzene) were detected at much lower concentrations (2-21 ug/kg). The presence of methylene chloride, chloroform, and benzene in this unit may be due to laboratory contamination, as these compounds were present in the method blank.

Contamination within the topsoil fill deposit consists of one metal (mercury), several volatile organic compounds and a number of base neutral extractables. Of the seven metals detected in the topsoil fill deposit, only mercury is present at concentrations (0.16-1.18 mg/kg) that exceed the limit for this metal in natural soils. Volatile organic contamination is very limited in extent within this unit. Detected volatile organics consist of eight compounds that are present in quantities below 20 ug/kg and in some cases within blank samples. The majority of contaminants present within this unit are base neutral extractables. All detected base neutrals were limited to sample 36 from TB-906, which is the uppermost surface sample from this area. A total of nineteen such compounds were detected at concentrations ranging from 7 ug/kg (acenaphthylene) to 1800 ug/kg (fluoranthene). All nineteen compounds consist of either polynuclear aromatic hydrocarbons (PAHs), which are coal tar derivatives or phthalate esters, which are plasticizers.

The extent of contamination within the lower silt/clay unit is limited in distribution. Of the detected metals, mercury was present in two samples from this unit at concentrations (0.42-1.66 mg/kg) above common range for natural soils. Only five volatile organic compounds, of which three are common laboratory contaminants, were detected. All five volatiles were present below 35 ug/kg and within method blank samples. The base neutral extractable compounds are limited to the area immediately north and south of the asbestos mound at TB-907 and TB-905, respectively. Twelve such compounds, mostly PAHs, were detected at TB-907 and five at TB-905. Phenols were also limited in extent and were only detected at TB-907 at a concentration of 5.7 mg/kg.

A concept level estimate of the quantity of contaminated soil on site is 957,500 cubic feet. This is a highly conservative worst case approach considering removal of all contaminated soil. These calculations are based on several assumptions. The first assumption is that the horizontal extent of contamination in the waste pile associated with TB-904, TB-903 and TB-902 is equal to the dimensions of the waste pile itself. The second assumption is that the horizontal extent of contamination around

TB-906 is 100 feet by 100 feet. These dimensions represent a conservative approach to the size of the disposal area. The third assumption is that the horizontal extent of contamination around TB-905 and TB-907 is considered to be 50 feet by 50 feet. However, soil calculations to quantify removal amounts to meet preliminary health risk Target Cleanup Levels (TCLs) indicate that no quantity of soil that needs to be removed based on unacceptable health risks. For a more detailed quantification of contaminated soils prior to any remedial actions, actual horizontal definition of the extent of contamination may have to be ascertained.

5.1.3 Groundwater Contamination. In November 1986 and June and October 1987, a total of three rounds of groundwater samples were obtained at the Millington Site to assess on-site groundwater quality. Sampling results from the three rounds indicate that volatiles, metals and asbestos were the primary constituents detected in the groundwater. Due to QA/QC problems in the laboratory, limited organic data is available for the second sampling round.

Of the detected volatile organics, only trichloroethene (2-6 ug/l) and benzene (2-50 ug/l) were indicated at concentrations above either USEPA Ambient Water Quality Criteria (AWQC) adjusted for drinking water only or Maximum Contaminant Levels (MCLs). In both of the first and third sampling rounds, trichloroethene levels in MW-903 and MW-905 exceeded its AWQC of 2.8 ug/l. Only the trichloroethene concentration (6 ug/l) in MW-905 on the first sampling round exceeded the MCL of 5 ug/l. Likewise, benzene was detected in MW-904 on the first sampling round and in MW-901, MW-902, and MW-906 on the third sampling above its AWQC of .67 ug/l. Only the benzene level (50 ug/l) in MW-902 exceeded the MCL of 5 ug/l.

Other volatiles detected above detection limits in the groundwater include trans-1,2-dichloroethene (5.8-6.0 ug/l) in MW-903, acetone (12-67 ug/l) in three wells (MW-901, 902, 903), ethyl benzene (21 ug/l) in MW-901 and xylenes (9.3 ug/l) in MW-901. With the exception of acetone, the concentrations of these compounds were below groundwater standards or criteria. No standards or criteria have been established for acetone. It

should be noted that the upgradient monitoring well screened in the bedrock (MW-901) contained the highest concentrations of volatile organic constituents (100 ug/l total volatiles) on the third sampling round. These results suggest that an off-site source may be affecting the bedrock aquifer.

Two base neutrals, bis (2-ethylhexyl) phthalate (2-400 ug/l) and naphthalene (2.6 ug/l), were detected above detection limits in the groundwater. Naphthalene, however, was only indicated in the bedrock well (MW-901) on the third sampling round. Bis (2-ethylhexyl) phthalate concentrations on all three rounds were below the AWQC of 21,000 ug/l. Although many base neutral compounds were detected in the soil samples collected from TB-906, these compounds were not indicated in the groundwater collected from MW-906. It is likely that these constituents are bound to soil particles and thus are not migrating to the groundwater.

Inorganic analyses indicate that both total and dissolved metals are present in groundwater. On the first sampling round, only dissolved metals were analyzed. Analyses for total metal constituents indicate that seven metals were detected in both the second and third rounds at concentrations exceeding groundwater quality standards or criteria. The seven metals included arsenic (6.2-7.0 ug/l), cadmium (4-19 ug/l), chromium (10-541 ug/l), copper (9.0-28,800 ug/l), lead (2.8-756 ug/l), mercury (2.6-10 ug/l) and nickel (15.0-352 ug/l). Ranges of concentrations provided are for both sampling rounds. The highest concentrations of total metals were indicated in MW-906 on both sampling rounds. Total metals levels at this location were an order of a magnitude higher than the other sampling location. The groundwater sample from MW-905 (and the duplicate sample 905) contained the next highest amount of total metals. The fact that MW-906 is situated in the vicinity of the former PMA disposal pits and that MW-905 is situated near a sewer outlet which collects water from the entire site including the area of the former PMA pit may explain why total metals concentrations are higher at these two locations.

It should be noted that total metal concentrations are probably indicative of the sediment concentrations in the groundwater as opposed to actual groundwater quality. Analyses of the dissolved metals content, discussed below, is more indicative of actual groundwater contamination.

Filtered groundwater samples were collected during all three sampling round for dissolved metals analysis. Concentrations of dissolved metals were significantly lower than those for total metals. Three metals, arsenic, mercury and nickel, were detected at concentrations exceeding groundwater standards or criteria. On the first round, mercury in MW-905 (5.6 ug/l), MW-906 (2.1 ug/l), MW-907 (2.5 ug/l) and MW-908, the duplicate of MW-905 (6.9 ug/l), were above the MCL 2.0 ug/l. On the second sampling round, mercury (4.8 ug/l) and arsenic in MW-902 exceeded MCLs and AWQC respectively. Nickel in MW-907 (49 ug/l) on the first sampling round, in MW-904 on the second round, and in MW-905 on both the second and third rounds of sampling exceeded the AWQC of 15.4 ug/l.

Asbestos contamination of groundwater was indicated in two monitoring wells located on the asbestos mound. MW-902 contained 79,809 fibers/ liter during the second groundwater sampling task and 58,800 fibers/liter during the third groundwater sampling task. MW-903 contained 88,210 fibers/liter and 142,000 fibers/liter during the second and third groundwater sampling tasks, respectively. The probable cause for the detection of asbestos in groundwater at these two locations is that the screen in these two wells penetrates the asbestos mound. Asbestos fibers may be moving directly into the monitoring wells during well sampling.

5.2 Surface Water Contamination

Three rounds of surface water samples were collected in September 1966 and June and October 1967 to determine whether the Millington Site was impacting the surface water quality. Results from the three rounds of samples indicate the presence of metals and asbestos in the surface water. Only one organic, methylene chloride, was detected in one sample collected from the storm drain discharge. Its presence, however, can

probably be attributed to field/lab contamination. In addition, the two detected phthalate esters, which are also common laboratory contaminants, were indicated in one sample collected upstream of the Millington Site.

Priority Pollutant metals detected in the Passaic River include cadmium, chromium, copper, lead, nickel, silver, selenium, and zinc. Of these metals, only cadmium and nickel were detected at concentrations exceeding MCLs or AWQC in the vicinity of the Millington Site. Nickel was detected in one sample (SW-1) collected immediately downstream of the Millington Site at a concentration of 47 ug/l which exceeds the AWQC of 13.4 ug/l. Cadmium (563 ug/l) was also detected immediately downstream of the site (SW-1) in the first sampling round. However, the fact that cadmium was not detected in any other surface waste sample from any of the other sampling round suggests that the cadmium concentration of 563 ug/l may not be representative of actual surface water conditions and should be considered an anomaly.

Of the remaining detected metals, copper, lead, and zinc were the most frequently detected. Copper was detected in the third sampling round at 8-10 ug/l. Levels of copper were higher upstream than downstream of the Millington Site. Lead was detected in the first and second sampling rounds at concentrations ranging from 2.5 - 22 ug/l. Zinc was detected in second and third round samples at concentrations ranging from 11-60 ug/l. The highest values of lead (22 ug/l) and zinc (60 ug/l) were indicated at the Commonwealth Water Company intake. In addition, the only detected values of silver (13 ug/l) and selenium (20 ug/l) were found at the Commonwealth Water Company intake.

Besides methylene chloride, the storm drain discharge (SW-00) contained five metals. Of these metals, only arsenic (15 ug/l) and nickel (24 ug/l) detected in the second sampling round were indicated at concentrations exceeding AWQC. The arsenic concentration was below the MCL of 5 ug/l. It should be noted that the storm drain collects run-off from the entire site in addition to Division Avenue. Thus, the source of metals in the storm drain discharge is not restricted to the Millington Site. Furthermore, the storm drain does not discharge directly into the

Passaic River, and therefore the discharge is not representative of surface water quality in the river.

Asbestos was indicated above detection limits in three surface water samples: SW-3 in the first sampling round, and SW-1 and SW-2 in the third sampling round when the laboratory achieved lower detection limits. SW-3 and SW-2, located upstream of the Millington Site, contained 100,000 fibers/ liter and 71,400 fibers/liter of asbestos, respectively. SW-1, located immediately downstream of the Millington Site contained 67,200 fibers/liter. Thus, there appears to be an upstream source of asbestos in the surface water.

5.3 Sediment Contamination

Two sediment samples were collected in the vicinity of the Millington Site as part of a regional surface water and sediment investigation of the Passaic River and its tributaries. The two sediment samples contained several base neutrals and metals along with one pesticide. No asbestos was detected above detection limits in the sediments.

Two volatiles, chloroform and toluene, and two base neutrals, di-n-butyl phthalate and bis(2-ethylhexyl)phthalate, were indicated in both samples in addition to the method blank, and thus are probably present as a result of laboratory contamination.

Besides three phthalate esters, detected base neutral compounds in the sediment samples consisted of polynuclear aromatic hydrocarbons (PAHs). Concentrations of PAHs in the downstream sample (SED-1) ranged from 16-400 ug/kg and totaled 1361 ug/kg, whereas levels of PAHs in the upstream sample ranged from 8-1400 ug/kg and totaled 7644 ug/kg. Possible sources of the PAHs are either degradation of biotic material or roadside runoff. Likewise, the pesticide, heptachlor, indicated in SED-1 at 5.7 ug/kg is probably present as a result of runoff from adjacent cultivated land.

Seven metals were detected in the sediment samples at concentrations ranging from 0.36 - 181 mg/kg. With the exception of nickel, the metals levels were higher upstream than downstream of the Millington Site. Only mercury (0.36 mg/kg) detected in the upgradient sample exceeded background levels for natural soils.

Thus, the sediment quality in the vicinity of the Millington Site is generally good. Additionally, the fact that base neutral and metal concentrations were higher upstream than downstream of the Millington Site suggests that the site is not impacting the sediments.

5.4 Source and Distribution of Contaminants. The overall source of contamination present at the site within the soils and groundwater appears to be the asbestos mound and associated fill material, and the area of the former PMA disposal pits located in the vicinity of TB-906. Laboratory analyses indicate that those soil samples collected at TB-906 contain the most amount of detected organic contaminants, particularly base/neutral compounds. Nineteen of these compounds were indicated in the surface sample from this test boring. Although volatile organic contaminants were found throughout the site, the highest number of detected volatile organics were found in soil samples from TB-906. The only metal of concern is mercury which is detected from soil samples collected throughout the site at concentrations above common range for natural soils. Considering that phenylmercuric acetate was dumped within the disposal pits, it is likely that the source of mercury is the disposal pits. Organic mercury, such as the PMA type, is more mobile than inorganic mercury and could move laterally and vertically through the subsurface.

Soil samples collected from the asbestos mound indicate that metals and volatile organic constituents are present within the asbestos waste material. Seven volatile organics were indicated in the asbestos waste at concentrations ranging from 0.39-301 mg/kg. Mercury is the only metal detected at concentration above common range in natural soils. All but one of the soil samples analyzed from this unit is above the water table

indicating that the contaminants are actually within the asbestos waste. The distribution of contaminants within the waste implies that the asbestos may be a source of contamination.

Analytical data for groundwater, collected during the second and third sampling tasks, indicate that the highest concentration of total metals, exceeding groundwater quality standards is at MW-905, MW-906 and MW-907. MW-906, screened in the vicinity of the former PMA disposal areas indicated the largest concentrations of total metals in the groundwater. MW-905 and MW-907, located south and north of the asbestos mound, contained the next highest amount of total metals. Topography appears to be the major factor controlling the distribution of contaminants in MW-905 and MW-907. The topography of the site slopes from the area of the disposal pits to the northwest, towards the vicinity of MW-907 and southwest towards MW-905. As a result groundwater flows primarily in these directions carrying contaminants from the source area. In addition, a storm drain outlet releases effluent collected from the Millington Site and along Division Avenue near MW-905. The storm drain may also act as a conduit for on-site contaminants and release them at the outlet area. If this scenario is valid, it is possible that MW-905 and the surface water (particularly downgradient of the site) could be impacted by the possible release of contaminants at the sewer outlet. However, surface water samples collected downstream of the Millington Site have not shown significant contamination.

6.0 ENDANGERMENT ASSESSMENT

6.1 Introduction

6.1.1 Purpose. This report contains a baseline risk assessment and toxicological assessment for the former National Gypsum plant in Millington, New Jersey. It is based on hydrogeological and chemical data obtained during the Remedial Investigation. The objective of this assessment is to define the health risks associated with the presence of hazardous contaminants on the site.

In order for a health risk to occur, there must be contaminants having known chemical and biological toxic characteristics present; there must be actual or potential exposure pathways; and there must be human and environmental receptors in the exposure paths. The baseline risk assessment procedure address these issues by analyzing the site from a source-pathway-receptor viewpoint and by evaluating possible health effects in the context of probable exposure scenarios.

This baseline risk assessment for the Millington Site is based primarily on validated chemical analytical data and hydrogeological conditions discussed in the Remedial Investigation Report and the assessment of contaminant migration pathways presented in Chapter 6.3. This Endangerment Assessment is designed to quantitatively assess current and future risks posed by the site. However, certain factors are inherently unable to be accurately quantified and therefore are assessed qualitatively.

6.1.2 Site Description and History. The Millington Site is located in the town of Millington in southeast Morris County, New Jersey. This site consists of an eleven acre commercial property that formerly housed a number of businesses that engaged in the fiberization and manufacture of

asbestos products. The site is bounded on the west by the Passaic River, on the north by the Millington Train Station and on the east and south by commercial and private residences, respectively.

Manufacturing of asbestos products at the site began in 1927 and continued through 1975. During this period, three separate companies operated for various lengths of time. Asbestos Ltd. engaged in the fiberization and sale of asbestos from 1927 until 1946. From 1946 until 1953, the plant was owned by Smith Asbestos, Inc., which manufactured asbestos roofing and siding. In May 1953, the National Gypsum Company acquired the property and manufactured asbestos siding and roofing sheets until 1975.

Asbestos contamination is present at the Millington Site as a result of the extensive asbestos manufacturing history associated with the site. An asbestos waste mound, 25-30 feet thick and composed principally of loose asbestos fibers, is located on the western sector of the property along the Passaic River. Water from the manufacturing process was impounded on the site by dams constructed to permit the settling of asbestos fibers suspended in the waste water. Periodically, sediment from the settling ponds was removed and transferred to the adjacent waste site and covered with dirt. Eventually, the asbestos waste mound grew to approximately 300 feet long and 70 feet wide.

In addition to the asbestos waste mound, subsurface asbestos waste in the form of discarded roofing sheets, fiber and siding litter a large portion of the Millington Site, along with broken chips of asbestos siding and roofing sheets.

During National Gypsum's period of ownership, an estimated 7.2 to 14.4 pounds of phenylmercuric acetate (PMA), which was used as a paint solvent, was disposed in pits located west of the main plant building.

6.2 Contaminants Found at the Site

Priority Pollutant compounds in soils, sediments, groundwater, and surface water have been detected as a result of environmental sampling. The presence of these compounds in various environmental media are summarized in the following sections.

6.2.1 Subsurface Soil. A total of thirteen subsurface samples were obtained by split spoon sampling from five test borings. Samples were taken from random intervals during the drilling process. The maximum depth for a sample was 33.5 feet in TB-902. Specific locations for each sampling location are detailed in Figure 3-1.

Of the metals detected, mercury most consistently exceeded the common range (0.01 to 0.3 ppm) for trace element background levels in soils (nine of eleven samples). Lead, nickel and zinc all exceeded the average background expected in natural soils (lead, 9/13 samples; nickel, 10/13 samples; zinc, 7/13 samples). Zinc exceeded the expected common range of 10-300 mg/kg for background ranges in natural soils in one sample (309 mg/kg). Table 6.2.1 lists the possible trace element content of natural soils as determined by the EPA.

Generally the highest concentration of metals were detected in downgradient test boring samples located on the asbestos fill deposits, which consisted of silty-clay topsoil fill, asbestos waste and an underlying silt/clay unit.

Five volatile organics were detected in the test borings. The highest quantities of contaminants and the greatest concentrations were found in two of the downgradient borings from the asbestos fill deposit (TB-902,903) and from the one upgradient boring TB-906. It should be noted that TB-906 is located in the area on site where phenylmercuric acetate, and possibly other materials, were dumped. Small quantities of phenols (less than 6 mg/kg) were detected in TB-903 (located on the asbestos fill) and TB-907 (located in the northwestern corner of the site). Table 6.2-2 summarizes the results of subsurface sampling.

TABLE 6.2-1

TRACE CHEMICAL ELEMENT CONTENT OF NATURAL SOILS

<u>Element</u>	<u>Common Range (ppm)</u>	<u>Average Range (ppm)</u>
Antimony	2-10	-
Arsenic	1-50	5
Beryllium	0.1-40	6
Cadmium	0.01-0.7	0.06
Chromium	1-1000	100
Copper	2-100	30
Lead	2-200	10
Mercury	0.01-0.3	0.3
Nickel	5-500	40
Selenium	0.1-2	0.3
Silver	0.01-5	0.05
Zinc	10-300	50

Reference: USEPA office of Solid Waste and Emergency Response, HAZARDOUS WASTE LAND TREATMENT, SW-874 (April, 1983) Page 273, Table 6.46.

TABLE 6.2-2

SUBSURFACE SOIL SAMPLING RESULTS

<u>Parameters (mg/kg)</u>	<u>Number of Samples</u>	<u>Number of Positive ID's</u>	<u>Sample Range¹</u>		<u>Sample Mean²</u>
			<u>Low</u>	<u>High</u>	
<u>Metals</u>					
Arsenic	13	2	2.3	6.0	4.2
Chromium	13	13	24.8	83.3	43.8
Copper	13	12	12.5	68.2	28.1
Lead	13	13	6.2	39.4	16.5
Mercury	13	11	0.1	7.8	2.0
Nickel	13	13	13.4	301.0	101.6
Zinc	13	13	17.5	309.0	66.3
<u>Cyanide</u>	13	4	0.1	0.17	0.12
<u>Volatile Organics</u>					
Methylene Chloride	13	10	0.02	0.15	0.06
Chloroform	13	5	0.01	0.02	0.01
Trichloroethene	13	1	0.08	0.08	0.08
Benzene	13	1	0.02	0.02	0.02
Toluene	13	7	0.01	0.08	0.04
<u>Phenols</u>	13	2	0.053	0.057	0.055

Notes:

1. Results do not include values below Contract Required Detection Limit (CRDL).
2. The sample mean is calculated only from those samples in which the parameter was detected, not the total number of samples.

6.2.2 Surface Soils. The approved sampling protocol dictated that soil removed at random intervals from the test borings would be utilized for contaminant analysis. A random numbers table was utilized to choose which of the intervals in all of the borings would be analyzed. As a result, only two surface samples were analyzed. These included the 0-2 foot intervals for TB-906 (upgradient of the asbestos fill area) and TB-907 (northwestern corner of the site).

Seven metals were detected in surface soils. Chromium (2/2 samples) was detected in concentrations below the average (100 ppm) for trace element background levels in natural soils. Arsenic (1/1 samples), copper (2/2 samples), lead (2/2 samples), nickel (1/2 samples) and zinc (2/2 samples) were found within the common range but higher than the average trace element content of natural soils. Mercury exceeded the common range (0.3 mg/kg) in one sample (1.66 mg/kg). Eleven base neutral compounds were found. The highest concentration and largest number of individual chemicals was found in TB-906. Concentrations ranged from 0.150 mg/kg of benzo(k)fluoranthene to 1.80 mg/kg of fluoranthene. Three volatile organics were detected. Concentrations ranged from 0.006 mg/kg of chloroform to 0.017 mg/kg of methylene chloride. Both of these compounds are suspected of being lab contaminants. Table 6.2-3 summarizes the surface soil sampling data.

6.2.3 Sediment. Sediment samples were obtained from the Passaic River in the area upstream and immediately downstream of the site (two samples) using a sediment coring device to penetrate the sediments. Sediment 1 is the downstream sample and Sediment 2 is the upstream sample.

Base neutral compounds were detected in both sediment samples. A total of nine base neutral extractable compounds were detected with concentrations of fluoranthene ranging from 0.40 mg/kg to 1.4 mg/kg in Sed 2. Seven metals were detected including arsenic, chromium, copper, lead, mercury, nickel and zinc. One volatile organic compound, toluene was detected with concentrations ranging from 0.012 mg/kg in Sed 1 to 0.015 mg/kg in Sed 2. It is important to note that concentrations of contaminants in sediments were much higher upstream of the site (Sed-2).

TABLE 6.2-3

SURFACE SOIL SAMPLING RESULTS

<u>Parameters (mg/kg)</u>	<u>Number of Samples</u>	<u>Number of Positive ID's</u>	<u>Sample Range¹</u>		<u>Sample Mean²</u>
			<u>Low</u>	<u>High</u>	
<u>Metals</u>					
Arsenic	2	1	7.4	7.4	7.4
Chromium	2	2	25.4	30.6	28.0
Copper	2	2	37.3	59.0	48.2
Lead	2	2	79.7	88.1	83.9
Mercury	2	2	0.2	1.7	0.9
Nickel	2	2	35.6	51.5	43.6
Zinc	2	2	82.1	82.7	82.4
<u>Volatile Organics</u>					
Methylene Chloride	2	2	0.011	0.017	0.014
Chloroform	2	1	0.006	0.006	0.006
Toluene	2	1	0.013	0.013	0.013
<u>Base-Neutral Extractables</u>					
Phenanthrene	2	1	1.20	1.20	1.20
Fluoranthene	2	1	1.80	1.80	1.80
Pyrene	2	2	0.09	1.70	0.89
Chrysene	2	1	0.88	0.88	0.88
Benzo(a)anthracene	2	1	0.72	0.72	0.72
Bis(2-ethylhexyl) phthalate	2	1	0.62	0.62	0.62
Benzo(b)fluoranthene	2	1	0.78	0.78	0.78
Benzo(k)fluoranthene	2	1	0.15	0.15	0.15
Benzo(a)pyrene	2	1	0.73	0.73	0.73
Benzo(g,h,i)perylene	2	1	0.57	0.57	0.57
Ideno(1,2,3 cd)pyrene	2	1	0.48	0.48	0.48

Notes:

1. Results do not include values below Contract Required Detection Limit (CRDL).
2. The sample mean is calculated only from those samples in which the parameter was detected, not from the total number of samples.

than downstream of the site (Sed-1). Total metal concentrations for Sed-2 were 379.46 mg/kg. For Sed-1 they were 227.9 mg/kg. Total organic concentrations for Sed-2 were 7.547 mg/kg. For Sed-1 they were 0.425 mg/kg. Table 6.2-4 summarizes the results of sediment sampling.

6.2.4 Surface Water. Surface water samples were taken in three separate sampling rounds over a period of a year. Values were summed across the period of study for the purpose of the endangerment assessment. Two surface water sampling locations were utilized upstream of the site to assess background conditions in the Passaic River; one sample location was located immediately downstream of the site (SW-1), and one sample location was located further downstream of the site (SW-22) at the Commonwealth Water Company. Organic compounds were not detected in these samples, probably as a result of their relatively high volatility in an aquatic environment. Cadmium (0.563 mg/l), chromium (0.02 mg/l) and nickel (0.047 mg/l) were detected in surface water sample SW-1. Concentrations of cadmium and nickel both exceeded their respective EPA Ambient Water Quality Criteria (adjusted for drinking water only at a 1×10^{-6} risk level cadmium, 0.01 mg/l; nickel, 0.0154 mg/l). The phthalates, bis (2-ethylhexyl) phthalate and di-n-butyl phthalate, were detected at concentrations ranging from 0.002-0.11 mg/l. Bis(2-ethylhexyl)phthalate, however, was only detected in the first sampling event and only at sample point SW-3 located approximately one mile upstream of the site. Asbestos was present in three samples at a concentration exceeding USEPA Ambient Water Quality Criteria (30,000 fibers/l). Table 6.2-5 summarizes the results of surface water sampling.

There were no significant trends that were noticed in levels of contaminants during the time period of the study. Cadmium and nickel were detected in the first round of sampling, but were not detected in the subsequent sampling events. It should be noted that, generally, total metal concentrations were higher immediately upstream (SW-2) than immediately below the site (SW-1). In round 2, total metal concentrations for SW-2 were 0.0408 mg/l as opposed to 0.0148 mg/l in SW-1. In round 3, total metal concentrations for SW-2 were 0.057 mg/l as opposed to 0.027 mg/l for SW-1. In round 1, SW-1 (downstream) did have a total metal

TABLE 6.2-4

SEDIMENT SAMPLING RESULTS

<u>Parameters (mg/kg)</u>	<u>Number of Samples</u>	<u>Number of Positive ID's</u>	<u>Sample Range¹</u>		<u>Sample Mean²</u>
			<u>Low</u>	<u>High</u>	
<u>Metals</u>					
Arsenic	2	1	10.9	10.9	10.9
Chromium	2	2	25.6	29.2	27.4
Copper	2	2	29.0	67.2	48.1
Lead	2	2	33.2	62.0	47.6
Mercury	2	1	0.4	0.4	0.4
Nickel	2	2	28.8	32.1	30.4
Zinc	2	2	108.0	181.0	144.5
<u>Volatile Organics</u>					
Toluene	2	2	0.012	0.015	0.014
<u>Base-Neutral Extractables</u>					
Phenanthrene	2	1	0.6	0.6	0.6
Fluoranthene	2	2	0.4	1.4	0.9
Pyrene	2	1	1.2	1.2	1.2
Chrysene	2	1	0.8	0.8	0.8
Benzo(a)anthracene	2	1	0.7	0.7	0.7
Benzo(b)fluoranthene	2	1	1.3	1.3	1.3
Benzo(a)pyrene	2	1	0.6	0.6	0.6
Benzo(g,h,i)perylene	2	1	0.5	0.5	0.5
Ideno(1,2,3,cd)pyrene	2	1	0.5	0.5	0.5
<u>Phenols</u>	2	1	0.001	0.001	0.001

Notes:

1. Results do not include values below Contract Required Detection Limits (CRDL).
2. The sample mean is calculated only from those samples in which the parameter was detected, not from the total number of samples.

TABLE 6.2-5

SURFACE WATER SAMPLING RESULTS

<u>Parameters (mg/l)</u>	<u>Number of Samples¹</u>	<u>Number of Positive ID's</u>	<u>Sample Range²</u>		<u>Sample Mean³</u>
			<u>Low</u>	<u>High</u>	
<u>Metals</u>					
Cadmium	12	1	0.563	0.563	0.563
Chromium	12	5	0.005	0.020	0.013
Copper	12	3	0.008	0.014	0.009
Lead	12	4	0.002	0.018	0.006
Nickel	12	2	0.047	0.084	0.065
Selenium	12	1	0.020	0.020	0.020
Silver	12	1	0.013	0.013	0.013
Zinc	12	7	0.011	0.060	0.025
<u>Base-Neutral Extractables</u>					
Bis (2-ethylhexyl phthalate)	14	1	0.110	0.110	0.110
Di-n-butyl-phthalate	14	1	0.013	0.013	0.013
<u>Phenols</u>	14	1	0.042	0.042	0.042
<u>Asbestos*</u>	15	3	67,200	100,000	79,533

* Units in Fibers (>5 microns) per liter

Notes:

1. Represents three sampling rounds of four samples each.
2. Results do not include values below Contract Required Detection Limit (CRDL).
3. The sample mean is calculated only from those samples in which the parameter was detected, not from the total number of samples.

SW-1 were driven by cadmium (0.563 mg/l) and nickel (0.047 mg/l) which were only seen in the first round. Tables 3.8-3, 3.8-5 and 3.8-6 summarize the sampling data by event.

Two samples (SW-00) were taken from runoff at the mouth of the storm drain located near TB-905. One volatile organic compound (methylene chloride) was detected along with five metals. Results for these samples are summarized in Table 6.2-6.

6.2.5 Groundwater. As with surface water, groundwater was sampled in three separate sampling rounds over a period of a year. In all three rounds, samples from the seven on-site wells were analyzed for asbestos, base neutrals, metals and VOCs. During the first sampling round, the samples were also analyzed for pesticides, PCBs, phenols and cyanide. No domestic water wells were sampled.

Eight metals were detected in groundwater samples analyzed for dissolved metals. It is considered that dissolved metals are of greatest concern because they are more indicative of what would be moving through the water table. Mercury exceeded the NJDEP Groundwater Quality Guideline of 0.0002 mg/l in 5 of 20 samples (exceeding concentrations range from 0.0021 to 0.0048 mg/l).

Two phthalate esters were present in five groundwater samples at concentrations ranging from 0.001 to 0.4 mg/l. Bis(2-ethylhexyl)phthalate was the most commonly detected phthalate. Groundwater standards have not been established yet for phthalates.

Six VOCs were detected in groundwater samples at concentrations ranging from 0.002-0.067 mg/l. Trichloroethene was found in four groundwater samples in concentrations ranging from 0.002 mg/l to 0.006 ug/l. Benzene was present in one sample at an estimated value of 0.050 mg/l.

TABLE 6.2-6

STORM DRAIN SAMPLING RESULTS

<u>Parameters (mg/l)</u>	<u>Number of Samples</u>	<u>Number of Positive ID's</u>	<u>Sample Range¹</u>		<u>Sample Mean²</u>
			<u>Low</u>	<u>High</u>	
<u>Metals</u>					
Arsenic	2	1	0.015	0.015	0.015
Copper	2	2	0.008	0.024	0.016
Lead	2	1	0.009	0.009	0.009
Nickel	2	1	0.024	0.024	0.024
Zinc	2	2	0.036	0.040	0.038
<u>Volatile Organics (mg/l)</u>					
Methylene Chloride	2	1	.003	.003	.003

Notes:

1. Results do not include values below Contract Required Detection Limit (CRDL).
2. The sample mean is calculated only from those samples in which the parameter was detected, not from the total number of samples.

There were no significant changes in levels of contaminants between each round. Tables 3.9-4, 3.9-6, 3.9-7, 3.9-8 and 3.9-9 summarize the results of the data by each event.

All groundwater samples were analyzed for asbestos fiber content and four positive results were obtained. Concentrations ranged from 58,800 to 142,000 fibers per liter. Table 6.2-7 summarizes the results of groundwater sampling.

6.2.6 Evaluation and Selection of Indicator Chemicals. In order to fulfill the requirements of an endangerment assessment, it is not necessary to thoroughly evaluate all contaminants detected on-site during the remedial investigation in terms of their concentrations, migration potential in various media, adverse health effects, degree of exposure and implications for public health. Certain indicator chemicals, rather than all compounds that were detected, were selected for the assessment. The indicator chemical selection process is designed to identify the "highest risk" chemicals at a site so that the public health evaluation is focused on the chemicals of greatest concern. Consequently, remediation of these critical contaminants should rectify any potential negative impacts associated with contaminants not selected for this evaluation.

The selection of indicator chemicals is based on procedures outlined in the Superfund Public Health Evaluation Manual (PHEM). Using this process, an Indicator Score is derived for each chemical on site. To arrive at an Indicator Score, the peak and representative concentrations for each chemical in each medium is multiplied by the appropriate toxicity constants (air, soil or water) for potential carcinogens and noncarcinogens identified in Appendices A-3 and A-5 of the PHEM. This generates a "CT" value (concentration times toxicity) for each chemical. The CT values are then summed across the media in order to produce the Indicator Score (IS) value. Essentially, the Indicator Score is a ratio between measured concentration and a toxicity-based benchmark that is used to rank the site chemicals. The chemicals on site are then ranked on the basis of the Indicator Scores.

TABLE 6.2-7
GROUNDWATER SAMPLING RESULTS

<u>Chemicals (mg/l)</u>	<u>Number of Samples¹</u>	<u>Number of Positive ID's</u>	<u>Sample Range²</u>		<u>Sample Mean³</u>
			<u>Low</u>	<u>High</u>	
<u>Metals</u>					
Arsenic	21	1	0.004	0.004	0.004
Chromium	21	12	0.005	0.023	0.013
Copper	21	10	0.008	0.386	0.060
Lead	21	2	0.012	0.020	0.016
Mercury	21	10	0.0002	0.0048	0.0023
Nickel	21	6	0.021	0.142	0.047
Silver	21	6	0.010	0.024	0.014
Zinc	21	17	0.012	0.158	0.054
<u>Volatile Organics</u>					
Acetone	21	4	0.012	0.067	0.028
Benzene	21	1	0.050	0.050	0.050
Ethylbenzene	21	1	0.021	0.021	0.021
Trans-1,2-dichloroethene	21	2	0.006	0.006	0.006
Trichloroethene	21	4	0.002	0.006	0.004
Xylenes (Total)	21	1	0.009	0.009	0.009
<u>Base-Neutral Extractables</u>					
Bis(2-ethylhexyl) phthalate	21	5	0.017	0.400	0.156
Di-n-butyl-phthalate	21	1	0.001	0.001	0.001
Napthalene	21	1	0.026	0.026	0.026
<u>Pesticides</u>					
Endrin	21	1	0.000026	0.000026	0.000026
<u>Phenols</u>					
	21	6	0.015	0.048	0.026
<u>Asbestos*</u>	21	4	58,800	142,000	92,205

*Units in fibers (>5 microns) per liter

Notes:

1. Represents three rounds of sampling.
2. Results do not include values below Contract Required Detection Limit (CRDL).
3. The sample mean is calculated only from those samples in which the parameter was detected, not from the total number of samples.

Final selection of Indicator Chemicals is not based solely on a numerical ranking or set of precise decision rules. Instead, a few general selection rules must be combined with site-specific and chemical-specific factors. The initial factor to consider is the relative Indicator Scores of the chemicals found at the site. In general, higher ranking chemicals based on representative IS values should be selected in preference to lower ranking chemicals within the toxicologic class (potentially carcinogenic or noncarcinogenic). In addition, potentially important exposure pathways at the site and chemical-specific factors are considered in the final selection of Indicator Chemicals.

Furthermore, chemicals for which toxicity constants have not been developed must be evaluated qualitatively to determine if they merit selection as Indicator Chemicals. Table 6.2-8 summarizes the IS scores for all substances found at the site which have toxicity constants. It also includes chemicals for which toxicity data is not available but which were deemed significant at the site due to a qualitative assessment of their toxicity and concentration on-site.

The following contaminants were chosen to be Indicator Chemicals: arsenic, cadmium, mercury, nickel, bis(2-ethylhexyl)phthalate, benzene, trichloroethylene, and asbestos. Table 6.2-9 summarizes the physical and chemical properties, where available, for each indicator chemicals.

6.2.6.1 Selection of Inorganics. Cadmium, arsenic and nickel were chosen on the basis of their high IS values. Mercury was chosen because of its relatively high ranking as well as its high frequency of occurrence.

The following metals appear to exceed background levels on a consistent basis: arsenic, mercury, nickel and zinc. Nickel was chosen as an Indicator Chemical because it had a much higher ranking than zinc. Arsenic was chosen because of its high ranking on both the PC and NC scales and because of its ubiquitous presence in all media. Cadmium was selected because of its high IS value and the fact that cadmium in surface

TABLE 6.2-8

RANKING FOR INDICATOR CHEMICAL SELECTION

<u>Chemical</u>	<u>IS Values</u>		<u>Ranking</u>		<u>IC</u>
	<u>PC</u>	<u>NC</u>	<u>PC</u>	<u>NC</u>	
Arsenic	6.34E-02	2.77E-01	1	4	Yes
Benzene	3.86E-04	5.85E-03	2	9	Yes
Benzo(a)pyrene	1.66E-04	9.71E-04	3	12	
Bis(2-ethylhexyl) phthalate	8.91E-05	-	4	-	Yes
Benzo(a)anthracene	2.10E-05	-	5	-	
Trichloroethylene	1.72E-05	-	6	-	Yes
Chloroform	1.69E-08	-	7	-	
Cadmium	-	2.51E+00	-	1	Yes
Selenium	-	2.10E+00	-	2	
Nickel	-	3.33E-01	-	3	Yes
Silver	-	2.80E-01	-	4	
Copper	-	4.56E-02	-	6	
Mercury	-	4.50E-02	-	7	Yes
Lead	-	1.88E-02	-	8	
Zinc	-	7.21E-03	-	9	
Phenol	-	4.20E-03	-	12	
Di-n-butyl-phthalate	-	4.95E-04	-	14	
Trans-1,2-dichloroethylene	-	3.17E-04	-	15	
Ethylbenzene	-	2.31E-04	-	16	
Methylene Chloride	-	2.76E-06	-	17	
Toluene	-	1.38E-08	-	18	
Asbestos	-	-	-	-	Yes

Key:

PC Potential Concern

NC Noncarcinogen

IC Indicator Chemical

IS Indicator Selection

TABLE 6.2-9

**SELECTED CHEMICAL PROPERTIES
OF INDICATOR CHEMICALS**

<u>Chemical</u>	<u>Molecular Weight</u>	<u>Water Solubility (mg/l)</u>	<u>Vapor Pressure (ppm Hg)</u>	<u>Henry's Law Constant (atm-m³/mole)</u>	<u>Log Kow</u>	<u>Koc (ml/g)</u>	<u>GW</u>	<u>Half Life (Days)</u>		<u>Air</u>
								<u>SW</u>	<u>Soil</u>	
Cadmium	112	NA	0.00E+00	NA	-	-	-	PERS	-	4.80
Mercury	201	NA	2.00E-03	NA	-	-	-	PERS	-	4.80
Nickel	59	NA	0.00E+00	NA	-	-	-	-	-	-
Bis(2-ethylhexyl)phthalate	391	-	-	-	-	-	-	-	-	-
Arsenic	75	-	0.00+00	-	-	-	-	PERS	-	5.00
Benzene	78	1.75E+03	9.52E+01	5.59E-03	2.12	83	-	1-6	-	6.00
Trichloroethylene	131	1.10E+03	5.79E+01	9.10E-03	2.38	126	-	1-90	-	3.70
Asbestos	NA	NA	NA	NA	NA	NA	-	PERS	-	4.80

1. PERS - Denoted persistent in that media.

2. Source of Information: Superfund Public Health Evaluation Manual EPA 540/1-86/060, 1986.

water is environmentally persistent. However, it must be noted that cadmium was found only in one surface water sample in the initial round of sampling. It was not observed in either the second or third round of sampling events. Mercury was selected because concentrations in groundwater exceeded the Primary Drinking Water Standard or the Maximum Contaminant Level (MCL) in five out of twenty samples.

Lead, copper and zinc were all ranked in the top ten based on concentration levels, but were not chosen as indicator chemicals because either their IS values were lower than the four metals selected or they were detected with much less frequency. Furthermore, because metals generally exhibit similar characteristics in terms of solubility, volatility and mobility, the four metals selected are representative of the metals found on-site.

Asbestos was chosen as an indicator chemical because of its high frequency of occurrence, its known carcinogenic effects, and its environmental persistence in an aquatic medium.

6.2.6.2 Selection of Organics. Bis(2-ethylhexyl) phthalate was selected as an indicator chemical because of its high IS value and ranking, its presence in all media, and its potential carcinogenicity. Although di-n-butyl phthalate was detected on-site, this chemical was not selected because of its low IS value and its reduced frequency of occurrence on-site. PAHs, while present in surface soil and sediment samples, were not chosen as indicator chemicals. The primary reason is their low concentrations in the media. The site has a total PAH concentration of 8.2 mg/kg. Edwards (1983) reports a world wide typical background range of PAHs in soil to be approximately 1.0 to 10.0 mg/kg, with the highest concentration being in urban areas. Noting this, the 8.2 mg/kg in surface soils at Millington could easily be attributable to background levels.

Benzene and trichloroethylene (TCE) were chosen because of their high IS values and ranking and because of their status as potential carcinogens. Benzene was detected in subsurface soil and groundwater from

TB-902 located on the asbestos mound. The groundwater sample of 0.050 mg/kg exceeded the Safe Drinking Water Act MCL of 0.005 mg/l. TCE was detected in groundwater at TB-903 and in subsurface soil at TB-902. The groundwater sample of 0.0058 mg/l exceeded the Safe Drinking Water Act MCL of 0.005 mg/l. Chloroform, toluene, methylene chloride and trans-1,2-dichloroethene were also ranked. However, because they were found at lower concentrations or with less frequency, or they were also found in the method blanks, they were not chosen as indicator chemicals.

6.3 Baseline Risk Assessment

6.3.1 Factors Affecting Migration.

6.3.1.1 Regional Geology/Hydrology. A detailed description of the geology and hydrology of the region is presented in Chapter 4.

6.3.1.2 Site-Specific Geology. The Millington Site is located within the Piedmont Physiographic Province and is situated between the second and third Watchung Basalts. The overall geology of the site is simple, consisting of a veneer of fill material that overlies a natural unconsolidated silt/clay unit that directly overlies bedrock.

The overlying fill deposit consists of reddish-brown silty to clayey topsoil fill and asbestos waste products (broken tiles, shingles, siding and loose fibers). Between the edge of the plant building and the asbestos waste mound, this fill deposit is between four and sixteen feet thick.

The underlying silt/clay unit consists of coarse-textured reddish-brown, silty-clay to clayey-silt that averages between 1 and 4.5 feet thick. This unit probably formed as a result of weathering of the underlying bedrock.

The underlying bedrock consists of coarse-grained siltstone that is reddish-brown in color. Distance to bedrock is shallowest along Division Avenue where it is only four and one-half feet below the surface. From

the edge of Division Avenue, the bedrock dips beneath the site toward the Passaic River, where it is encountered at 4-16 feet beneath the main area of the site and 25-30 feet beneath the asbestos mound.

6.3.1.3 Site-Specific Hydrology. The uppermost water-bearing zone at the Millington Site is the silt/clay unit that lies directly over bedrock. This unit is found at a depth ranging from 1 to 30 feet below the surface and ranges in thickness from 1 to 4.5 feet across the site.

Groundwater elevations measured on 11/29/86 were plotted and contoured to determine groundwater flow paths at the site. Groundwater was found to be flowing in an westward direction toward the Passaic River in the direction of dip of the bedrock. The hydraulic gradient has been established between TB-901, TB-906 and the 5 downgradient wells in the upper water-bearing zone as 0.047 feet/foot.

Hydraulic conductivity measurements in the silt/clay unit range from 2.89 to 5.01 feet per day (ft/day). The average of these measurements (3.97 ft/d) was used to determine the rate of groundwater flow. The specific discharge through the unit was calculated to be 68.1 feet per year, while the seepage velocity (true velocity) was determined to range between 206.3 to 227 feet per year. Chapter 4 presents a detailed assessment of the site hydrology.

6.3.1.4 Climatology. Millington is in the Passaic River Basin. Climate for the area is typical of the entire Middle Atlantic Seaboard. Winters are moderate with moderate snowfall. Summers are moderate with frequent thunderstorms. Average annual temperature is approximately 54°F. The mean annual relative humidity varies from 67% to 73%. Prevailing winds are from the northwest, with an average annual velocity of about 9.7 miles per hour.

Average precipitation is approximately 47.3 inches. The 24-hour maximum rainfall is 2.8 inches. The distribution of precipitation throughout the year is fairly uniform. Average snowfall is about 34.2 inches.

6.3.2 Environmental Fate.

6.3.2.1 Soils. Chemicals present in soils are subject to several fate processes. These include sorption onto soil particles, dissolution into infiltrating precipitation and transport through groundwater, biodegradation by microorganisms and uptake by plants and animals. Volatile organic compounds in soils may infiltrate through the soil and escape to the atmosphere, but this is a very slow process under normal conditions. The primary fate determinants for chemicals in soils are the degree to which those chemicals absorb onto soil particulates and the rate at which those compounds are degraded by microorganisms. Chemicals which absorb strongly onto soil particulates are not significantly leached out by infiltrating precipitation. They are relatively immobile and may be persistent in the environment. Chemicals which do not absorb strongly onto soil particles, on the other hand, will leach out of soils and are transported via groundwater. These chemicals can then be dispersed by the groundwater flow system and their concentrations can be diluted. Biodegradation is a major factor in the persistence and ultimate fate of many chemicals in the environment because it acts to decompose compounds into by-products of the original compound. These products may exhibit different properties than the parent compound, resulting in more or less mobility, persistence and toxicity than the parent compound.

The contaminants of concern in soils on-site are primarily metals. Metals adsorb strongly to soil particles and are not likely to leach out of the soil into groundwater. As such they would be persistent in the soil. Due to the relatively low solubility of metals, significant transport of these compounds has not occurred. The low levels of metals detected in surface water and groundwater substantiate this conclusion.

Of the other chemicals detected on site in soils, volatile organics were detected in the highest concentrations in subsurface soils, while the lowest concentrations were found in the surface soil samples. This is a logical occurrence considering the volatilization fate process. Base neutral extractables (primarily PAHs and phthalate esters) were located almost exclusively in the surface soil samples. This is expected because

these chemicals generally have higher Koc values and are less water soluble than volatile organics and as such tend to leach more slowly into groundwater. Asbestos is present in significant quantities in the soil. Generally, asbestos tends to be a very stable mineral. However acidic conditions can cause a dissolution of the laminate structure of the asbestos fiber. The rate or possibility of this occurring on site is unknown.

Soils in and of themselves are not transport media. The movement and fate of chemicals of concern that are present in the soil are discussed in sections dealing with air, surface water and groundwater.

6.3.2.2 Surface Water. Metals were the primary contaminants detected in surface water samples throughout all three rounds of sampling. There are no generalized trends in metal concentrations over the three sampling events, nor were there clear trends in all metal concentrations as compared to sample location (upstream or downstream). In the second sampling round, lead and zinc were approximately in roughly the same concentrations across the sampling locations (lead: 0.0025 mg/l-upstream, 0.0028 mg/l-immediately upstream, and 0.0028 mg/l-immediately downstream; zinc: 0.012 mg/l-immediately upstream, 0.012 mg/l-immediately downstream, 0.016 mg/l-downstream). In the third round, copper and chromium were found in equal measures at the sampling locations (copper: 0.01 mg/l upstream, 0.008 mg/l-immediately upstream, 0.008 mg/l-immediately downstream; chromium: 0.005 mg/l-upstream, 0.005 mg/l-immediately downstream).

Metals in surface water tend to be removed from the water column by adsorption onto particulate matter and precipitation into the sediments. This process is illustrated at this site. The same metals found in surface water were also found in sediments though at significantly higher concentrations. The proximity of contaminated surface soil to the river indicates the possibility that runoff could have accounted for some of contaminant levels in sediments. It must be noted, however, that the highest levels of contamination in sediments are in the Sed-2 sample upstream. The majority of the contaminants in the sediments are PAHs with

the total quantity of PAHs falling within possible background levels. Further, surface runoff could contribute to contaminants directly to the surface water. This scenario does not seem to be evident noting the low concentration levels of contaminants downstream. However, under certain conditions (i.e. flooding) the incidence of surficial intrusion of contaminants into the Passaic River via runoff may be increased.

There were no volatile organics detected, probably as a result of their relatively high volatility in an aquatic environment. Asbestos is relatively insoluble in water, yet will remain in suspension for an extended period of time. Asbestos is generally not susceptible to biological or chemical degradation in aquatic media.

6.3.2.3 Groundwater. The uppermost aquifer at the site is within the unconsolidated silt/clay unit that lies directly over bedrock. The effective porosity of the silt/clay unit was estimated to be approximately 30-33 percent. The real velocity of the groundwater was calculated to be 206.3-227 feet/year. Groundwater elevations indicate that groundwater is flowing in an westward direction towards the Passaic River, under the influence of bedrock topography.

Of the contaminants of concern, metals and bis(2-ethylhexyl) phthalate are relatively insoluble, and as such do not move readily through groundwater. This is supported by the relatively high concentrations of metals in soil as compared to the groundwater. It is further reinforced by the difference in total metals in groundwater versus dissolved metals. Total metals (water and entrained sediment) analyses indicated much higher concentrations than dissolved metals (just water and therefore more indicative of what would be moving through groundwater). The more soluble volatile organics, while low in frequency, were closer in concentration level to those levels in subsurface soil. Asbestos is present in groundwater samples. It is not clear as to whether this is indicative of asbestos suspended in the well as a result of fiber movement from the surrounding asbestos fill material, or asbestos is actually being transported via groundwater. Due to the insolubility of asbestos, it is conceptually possible that fibers smaller than the porosity of the soil

could move through groundwater, but actual rates are not known. For all contaminants of concern, except asbestos, the primary mechanisms which act to reduce concentrations are dilution and dispersion.

There are no general trends that were observed based on the concentration levels for the contaminants of concern across the three sampling rounds.

6.3.2.4 Environmental Fate and Transport of Indicator Chemicals. The information presented in this section is derived from Water-Related Environmental Fate of 129 Priority Pollutants (USEPA, 1979) and EPA Health Effects Assessment Documents for individual chemicals. Information on environmental fate is presented in Table 6.2-9.

6.3.2.4.1 Cadmium. Although cadmium is more mobile in the aquatic environment than other heavy metals, it is not expected to move rapidly through the environment. It may be transported in solution as either hydrated cations or as organic or inorganic complexes. It is naturally found in the zero and +2 valence states. Sedimentation occurs through sorption onto clays or organic matter, co-precipitation and isomorphous substitution in carbonate materials. Although the fate of cadmium in soil has not been thoroughly studied, it is expected that cadmium is strongly sorbed onto soil and that sorption increases with an increase in organic matter content. Although sorption processes control the environmental fate of cadmium less than other heavy metals, sorption probably removes more cadmium from solution than precipitation and thus controls the ultimate fate of cadmium. This renders it persistent in the environment.

6.3.2.4.2 Mercury. Mercury is unique in that it is the only metal that exists as a liquid at room temperature. It is found in three oxidation states: elemental (Hg^0), mercurous ion (Hg^{+1}), and mercuric ion (Hg^{+2}). The most reduced form, elemental mercury is a liquid at room temperature, is slightly soluble in water, and has a tendency to volatilize. It can be part of both organic and inorganic compounds. Mercury is most water soluble and most toxic in the mercuric (+2)

oxidation state. Most mercury found in aquatic environments is removed through adsorption onto particulates and subsequent sedimentation. Small portions of dissolved mercury (Hg^{+2}) may be ingested by microorganisms, undergo methylation and bioaccumulate through the food chain. The resulting compound, methyl mercury, is the most hazardous and biologically persistent of the mercury species because it is readily accumulated in aquatic biota. Although mercury binds strongly to soil, transport through groundwater is still possible since bacteria in sediments can result in remobilization.

6.3.2.4.3 Nickel. Nickel is one of the most mobile metals in the aquatic environment. It is stable and may migrate long distances. Although nickel exists in the 0, +1, +3 and +4 valence states, the majority of nickel is found in the +2 valence state. Nickel has a relatively high affinity for organic materials, hydrous iron and manganese oxides. It exists in solution as hydroxide, carbonate, sulfate and organic complexes. Toxic levels of nickel may be reached in solution because of the relatively high level of solubility of the hydroxide, carbonate, sulfate and halide compounds under anaerobic conditions. Although the fate of nickel in soil has not been well studied, it is thought that soils with relatively high proportions of iron and manganese oxides will significantly adsorb nickel. The mobility of nickel is enhanced in soils with high organic matter concentration due to complexation. Nickel does not volatilize from the aquatic environment. In general, nickel does not bioaccumulate in significant quantities in aquatic organisms.

6.3.2.4.4 Bis(2-ethylhexyl)phthalate. Bis(2-ethylhexyl)phthalate (DEHP) readily adsorbs onto suspended particulates biota, and organic matter in an aquatic media and soils. Under certain conditions it is likely to form a water soluble complex with humic material. Volatilization is considered to be a possible fate process for this compound because of the low solubility, although the strong sorption potential of DEHP may reduce volatilization to insignificant levels. Bioaccumulation is a significant fate process. Biodegradation occurs in mixed microbial systems under aerobic conditions. Hydrolysis does occur

in the water column, but may be too slow to be environmentally significant. Biotransformation is probably an important aquatic fate process for DEHP, although detailed information concerning the environmental significance of this process is not available.

6.3.2.4.5 Arsenic. Arsenic is extremely mobile in the aquatic environment, cycling through the water column, sediments and biota. Arsenic (As) has multiple oxidation states and is naturally found in the 3-, 0 (metallic), 3+, and 5+ valence states. As ⁺⁵ is the dominant species in aquatic systems. Biological activities may reduce it to arsenite (As⁺³) and then to methylated arsenide (As⁻³). Arsenic is sorbed from aquatic media onto clay, iron oxides and particulate matter high in organic content. An increase in aquatic mobility results from the metabolism of precipitated arsenic by aquatic organisms. Arsenic has been found to bioaccumulate but not in large concentrations. Leaching of arsenic from soils of low adsorptive capacity (i.e. soils with low organic matter content) may occur. Arsenic is not volatile under normal conditions.

6.3.2.4.6 Benzene. Volatilization is the predominant process for removal of this compound from aquatic systems. That portion of benzene which is volatilized into the atmosphere is though to be depleted at a fairly rapid rate due to attack by hydroxyl radicals. However, this compound is also relatively soluble in water. Consequently, persistence of some benzene in the aquatic system is expected. The propensity for benzene to adsorb onto soil particles and sediments has not been well defined, although it appears that adsorption processes may be significant for benzene under conditions of constant exposure. There is evidence of gradual biodegradation of benzene at low concentrations by aquatic microorganisms. In addition, the rate of benzene biodegradation appears to be enhanced when other hydrocarbons are present. The bioaccumulation potential of benzene by aquatic organisms at concentrations anticipated in environmental waters is expected to be low.

6.3.2.4.7 Trichloroethylene. Trichloroethylene (TCE) is known to be ubiquitous in the environment. It has been detected in drinking water

supplies, marine water, rainwater, food, human tissues and in the atmosphere. This suggests that there is a general background level in the parts per billion range which pervades the atmosphere, hydrosphere and biosphere. Volatilization is the primary environmental transport process for TCE, and transfer from the aqueous phase to the atmosphere is quite rapid. In groundwater, adsorption onto organic matter does not appear to be an important process. This enables TCE to move with groundwater and not be significantly retarded by aquifer materials. Literature references to microbial biodegradation of TCE are few and conflicting, although the majority of these references suggest that TCE is not readily degraded by microorganisms. There is no evidence to suggest that this compound is biomagnified in aquatic food chains. TCE is reported to have a half-life of 3.7 days in air, 1-4 days in rivers, and 30-90 days in lakes.

6.3.2.4.8 Asbestos. Asbestos is a stable, naturally occurring mineral known for its ability to form relatively soft, silky fibers. While there are several definitions for the term asbestos, the definition currently used by EPA is from the notice of proposed rule-making for "Occupational Exposure to Asbestos" published in the Federal Register (October 9, 1975; pp. 47652, 47660) by the U.S. Occupational Safety and Health Administration (OSHA). Asbestos form minerals are divided into two main classes: serpentine and amphibole. Chrysotile asbestos is the only member of the serpentine class and comprises more than 95 percent of the asbestos fibers produced today. There are presently five known types of amphibole: crocidolite, amosite, anthophyllite, tremolite and actinolite. The minerals chrysotile, amosite, crocidolite, tremolite, anthophyllite and actinolite are classified as "asbestos" if the individual crystal fragments are greater than 5 micrometers in length, less than 5 micrometers in diameter, and have a length to diameter ratio of three or greater.

In the aquatic environment, asbestos is not prone to significant chemical or biological degradation. Photolysis does not occur and volatilization occurs at insignificant levels. Bioaccumulation has not been observed in aquatic organisms and biotransformation does not occur. Chemical speciation is a possible fate process; dissolution of chrysotile materials has been observed. Asbestos does not have an adsorptive

affinity for chemicals normally found in natural water (aquatic) systems. However, some primarily organic compounds and trace metals, have an affinity for adsorbing asbestos materials. Once introduced into a surface water system, asbestos will tend to remain in suspension until physical and chemical degradation or physical agitation allows it to settle into bottom sediments.

6.3.3 Exposure Pathways. An exposure pathway consists of four necessary elements: (1) a source and mechanism of chemical release to the environment, (2) an environmental transport medium (e.g. air, groundwater), (3) a point of potential human or aquatic life contact with the contaminated medium, and (4) a human or aquatic life exposure route at the contact point (e.g. drinking water ingestion). If all four elements are present, then the pathway is said to be complete and a present risk would be evident. If all four elements are present, but exposure point concentrations are very low, then the pathway is complete but a risk may not exist. While the absence of one of the elements would render the pathway incomplete and therefore, prevent expression of the risk, future changes at a site (i.e. proposed development) could add back an element, complete the pathway and present a future risk to human health, welfare and/or the environment. Table 6.3-1 summarizes the exposure pathways for the Millington site.

6.3.3.1 Soil. Exposed asbestos waste material consists of an asbestos waste mound and asbestos chip debris scattered on the surface of the Millington Site. Both these asbestos deposits are described in Chapter 6.2. The landfilled asbestos waste consists of a subsurface waste deposit composed of pieces of asbestos roofing, siding and loose asbestos fibers. This deposit is relatively shallow and was encountered at 8 feet below the surface during test boring activities and is approximately 7 feet thick.

The transport mechanisms for release of soil along this exposure pathway consist of site leaching into groundwater, surface run-off, tracking and fugitive dust generation.

TABLE 6.3-1

MATRIX OF POTENTIAL EXPOSURE PATHWAYS: MILLINGTON SITE

<u>Use/Transport Medium</u>	<u>Release/Source Medium</u>	<u>Exposure Point(s)</u>	<u>Exposure Route(s)</u>	<u>Pathway Complete</u>
Ground Water	Exposed asbestos pile and chips/ Site leaching	Potable Wells Passaic River	Ingestion Direct Contact Ingestion (fish) Ingestion (drinking water)	No ¹ Yes Yes No ²
Surface Water	Exposed asbestos pile and chips/ Surface runoff	Passaic River Ingestion (water)	Direct Contact Ingestion (fish)	Yes Yes No ²
Surficial Soil	Exposed asbestos pile and chips, and landfilled asbestos waste/ Site leaching surface runoff fugitive dust generation tracking	Site itself	Direct Contact Ingestion	Yes Yes

ii

This pathway is incomplete because no wells exist between the site and the Passaic River, which is the groundwater discharge area.

This pathway is incomplete because surface water drawn from the Passaic River 10 miles downstream of the site is mechanically and chemically treated to remove any contaminants prior to discharge as drinking water to local residences. Other wise, the Passaic River is not used as a source of potable water.

Site leaching involves transportation of the asbestos waste down into the subsurface soils via percolating water. Surface run-off has a major transport medium involving the asbestos waste mound. Samples collected from run-off from the asbestos mound during rains contained asbestos fibers. Furthermore, slump structures of the asbestos mound observed along the Passaic River indicate erosion is possible surface run-off. Fugitive dust generation and tracking are two possible potential transport mechanisms.

The only exposure point for the soil exposure pathway is Millington Site itself. As previously stated, the site is currently active, and houses twenty-one businesses employing approximately 150 personnel. Exposure routes consist of either direct contact through activity on the site or the more remote possibility of ingestion of contaminated soils. The Millington Site is the long term human exposure point for the soil media.

6.3.3.2 Surface Water. Release media present in the surface water at the Millington Site consist of the previously described aerially deposited asbestos waste pile and asbestos chips.

Surface run-off from the Millington Site, especially in the vicinity of the asbestos waste mound, is the only transport mechanism for surface water exposure pathway. Surface water run-off only occurs during and immediately following long periods of heavy rainfall. Asbestos fibers from the asbestos waste mound can easily be exposed and entrained in surface run-off. It has been postulated that the asbestos chips scattered on the surface of the site may dissolve under the influence of acid rain which could potentially release asbestos fibers into the environment. Exposed asbestos fibers could then also be entrained by surface run-off. The ultimate discharge of the surface run-off is the nearby Passaic River.

The major exposure point for the surface water exposure pathway is Passaic River. Human exposure routes consist of direct contact with Passaic River and ingestion of fish removed from the river.

6560 002 854

TABLE 6.3-2

TOXICITY PARAMETERS OF INDICATOR CHEMICALS AT
THE MILLINGTON SITE

<u>Critical Contaminant</u>	<u>Acute Toxicity mg/kg of Body Weight (a)</u>	<u>Chronic Toxicity PPCLS (b)</u>	<u>EPA Drinking Water Health Advisories ppb (ug/L) (c)</u>	<u>Bioconcentration Factor BCF (c)</u>	<u>Carcinogen Status (a)</u>	<u>TLV mg/m³ (e)</u>	<u>IDLH (f)</u>
Cadmium	Oral Rat LD50: 225	0.00449 ug/l UCR 10 ug/l MCL	1 day: 43 10 day: 8 Lifetime: 18	81	Human Possible	0.05	Ca
Mercury	---	10 ug/l ADI 2 ug/l MCL	Lifetime: 5.5	5500	Not Classified	0.1	28 mg/m ³
Nickel	Oral Rat TDLo: 158 mg/kg	750 ug/l ADI 0.0304 ug/l	10 day: 1000 Lifetime: 350	47	Human Probable	0.1	Ca
Bis(2-ethylhexyl) phthalate	Oral Rat LD50: 26 mg/kg	21,000 ug/l ADI	---	380	Animal Positive	---	---
Arsenic	Oral Mouse TDLo: 120	50 ug/l MCL	1 day, 10kg child: 50 10 day, 10kg child: 50	44	Human Definite Animal Possible	0.2	Ca
Benzene	Oral Rat LD50: 3800 Oral Imm TDLo: 130 (CNS Effects)	0.66 ug/l UCR 5 ug/l MCL	1 day, 10 kg child: 233 10 day, 10 kg child: 233 (ignores carcinogenicity of benzene)	5.2	Human Suspected	30	Ca
Trichloroethylene	Oral Rat LD50: 7000	1.84 ug/l UCR 2.80 ug/l UCR 5 mg/l MCL (d)	---	10.6	Human Probable	270	Ca
Asbestos	---	---	---	0	Human Carcinogen	0.5 Fibers/cc (amosite)	Ca

Notes:

1. The lack of available data in the literature on certain critical contaminants does not imply that associated health impact are not present.
2. PPCLs or preliminary protective concentrations limits are suggested exposure limits at the point of consumption. These values assume exposure of a 70 kg adult consuming 2 liters of water per day for a 70-year lifetime exposure.
3. EPA Drinking Water Health Advisories are given for a 10 kg child for the one-day and ten day values. Longer term health advisories are for exposures ranging from several months to several years and should generally be compared only to estimated short-term concentrations (STC). The first value is for a 10 kg child and the second value is for a 70 kg adult. Lifetime values are for a 70 kg adult.
4. CNS = Central Nervous System effects.

TABLE 6.3-2 (CONTINUED)

TOXICITY PARAMETERS OF INDICATOR CHEMICALS AT
THE MILLINGTON SITE

Sources:

- (a) Dangerous Properties of Industrial Material, Sixth Edition, 1984, Van Nostrand Reinhold Company, Inc.
- (b) Pollution Control Engineer's Handbook, 1985, Pudvan Publishing Company.
- (c) Superfund Public Health Evaluation Manual, USEPA Document Number EPA 540/1-86/060, October 1986.
- (d) 52 Federal Register 25690-25717, July 8, 1987.
- (e) Threshold Limit Values and Biological Exposure Indices for 1987-1988, American Conference of Governmental Industrial Hygienists Document.
- (f) Pocket Guide to Chemical Hazards, DHHS (NIOSH) Document 85-114, September 1985. Where the notation "Ca" appears, human carcinogen: IDLH's are not listed for those substances. 'N/A' indicates that an IDLH (Immediately Dangerous to Life and Health Level) has not been assigned.

TABLE 6.3-3

**SELECTED TOXIC IMPACTS OF INDICATOR CHEMICALS AT
THE MILLINGTON SITE**

<u>Critical Contaminants</u>	<u>Adverse Health Effects/Health Hazards</u>	<u>Mutagenicity Bioassays</u>	<u>Reported Reproductive Effects</u>	<u>Reported Tumorigenic Effects</u>
Cadmium	<ul style="list-style-type: none"> • Renal dysfunction • Disturbances in mineral metabolism • Kidney stone formation 	Mixed Results	Low dose (0.1 mg/L) has no effect in rats; high dose (10mg/L) may result in decrease fertility; runting and deaths in rat offspring	---
Mercury	<ul style="list-style-type: none"> • Metallic mercury may cause contact dermatitis • Methyl mercury affects the Central Nervous System 	Not available for inorganic mercury	---	---
Nickel	<ul style="list-style-type: none"> • Skin allergies/dermatitis following dermal contact 	Nickel chloride and nickel sulfate have been shown to be mutagenic in eukaryotic systems	No effects at 500 ppm; maternal weight loss, reduction in mean birth weight of pups and increase incidence of spontaneous abortion	Exposure to nickel sulfide induced adenomas and adenocarcinomas of the lung in mice
Bis(2-ethylhexyl)phthalate	<ul style="list-style-type: none"> • Liver damage • Testicular degeneration 	Results are positive	Testicular atrophy and seminiferous tubule degeneration	Hepatocellular carcinoma
Arsenic	<ul style="list-style-type: none"> • Severe gastrointestinal distress • Impaired hematopoiesis • Renal/hepatic necrosis • Peripheral neuropathy 	Arsenic Compounds have been observed to produce chromosomal damage <u>in vitro</u> and <u>in vivo</u>	High oral doses during pregnancy may damage fetus	Negative results
Benzene	<ul style="list-style-type: none"> • Depressed central nervous system • Immunological effects • Bone marrow depression, hematotoxin • Known leukemogen • Locally strong irritant 	Negative in Ames assay, positive for inhalation tests Decreased DNA Synthesis <u>in vitro</u> in animal bone marrow cells & cultured human cells	Negative reproductive effects in pregnant mice	Tumors of the oral cavity and skin in rats and increased incidence of lung, ovary and mammary gland tumors in mice Increased incidence of thymic lymphoma in mice (300 ppm, via inhalation)
Trichloroethylene	<ul style="list-style-type: none"> • Depressed central nervous system • Increase liver/kidney weights • Changes in cerebellum 	Results are positive	Slightly reduced fetal body weights, delayed skeletal development and an increase in incidence of undescended testes in mice (via inhalation)	Hepatocellular carcinoma, lung adenocarcinoma

TABLE 6.3-3 (CONTINUED)
SELECTED TOXIC IMPACTS OF INDICATOR CHEMICALS AT
THE MILLINGTON SITE

<u>Critical Contaminants</u>	<u>Adverse Health Effects/Health Hazards</u>	<u>Mutagenicity Bioassays</u>	<u>Reported Reproductive Effects</u>	<u>Reported Tumorigenic Effects</u>
Asbestos	<ul style="list-style-type: none"> • Diffuse interstitial fibrosis • Calcification/fibrosis of the • Cuboidal metaplasia of the alveolar epithelium • <u>Cor pulmonale</u> • Asbestosis 	Results are positive	Not reported	Bronchogenic carcinomas, mesothelioma, digestive tract carcinoma

1. Sax, N.I. Dangerous Properties of Industrial Material. Sixth Edition, 1984. Von Nostrand Reinhold Co., New York.
2. USEPA Health Effects Assessment for Arsenic, September 1984, EPA/540/1-86/020
3. USEPA Health Effects Assessment for Asbestos, September 1984, EPA/540/1-86/049
4. USEPA Health Effects Assessment for Benzene, September 1984, EPA/540/1-86/037.
5. USEPA Health Effects Assessment for Cadmium, September 1984, EPA/540/1-86/038.
6. USEPA Health Effects Assessment for Mercury, September 1984, EPA/540/1-86/042.
7. USEPA Health effects Assessment for Nickel, September 1984, EPA 540/1-86/018.
8. USEPA Health Effects Assessment for Trichloroethylene, September 1984, EPA/540/1-86/046.
9. Verschueren, K. 1983. Handbook of Environmental Data on Organic Chemicals. Von Nostrand Reinhold Co., New York.

however, there is significant risk of lung cancer following inhalation exposure. Mixed results were obtained from mutagenicity testing. Low doses (0.1 mg/l) did not exhibit a teratogenic effect in rats; however, high doses (10 mg/l) resulted in decreased fertility, runting and young deaths.

Cadmium is poorly absorbed in humans following oral administration. Long term exposures cause renal dysfunctions leading to disturbances in mineral metabolism and ultimately kidney stone formation. Cadmium has also been correlated with hypertension in humans.

6.3.4.2 Mercury. Mercury is a metal found in Group II B of the periodic table. It is unique in that mercury exists in a liquid at room temperature. Mercury exists at three oxidation states in the environment: 0 (elemental), +1 (mercurous compounds) and +2 (mercuric compounds). Metallic mercury has a vapor pressure of 1.2×10^{-3} mm Hg at 20°C and a water solubility of 81.3 ug/l at 30°C (Callahan et al, 1979). Mercurous compounds are generally less water soluble than the mercuric compounds. Mercury forms a variety of organic compounds, including methyl mercury, ethylmercury, phenylmercury and alkoxyphenylmercury. Generally these organo mercury compounds are toxicologically and environmentally important.

The physiological effects of mercury are dependent on the type of mercuric compound. Metallic mercury may cause contact dermatitis characterized by papular erythema with slight hyperkeratosis after prolonged skin contact. The vapors of metallic mercury cause systemic effects such as erethism, tremor and gingivitis. Some cases of albuminuria and proteinuria have also been reported as a result of mercury vapor inhalation. Salts of mercuric mercury can produce acute renal failure if ingested as a single dose. The lethal dose of HgCl_2 has been estimated to be approximately 1 to 4 grams for human adults. Neurological changes are also thought to be associated with intoxication by inorganic mercury. Children exposed to salts of inorganic mercury may develop acrodynia. The CNS is the primary locus of action for methylmercury. Symptoms found through progressively severe cases of poisoning include;

paresthesia, malaise, blurred vision, bilateral constriction of the visual fields, deafness, dysarthria, ataxia, mental derangement, coma and death (USEPA, 1984).

Inhalation and ingestion are considered the two major pathways for mercury poisoning. Metallic mercury is poorly absorbed through the GI tract. It is, however, rapidly absorbed in vapor form through the lungs. Some experiments show approximately 80% of metallic mercury is absorbed. Methylmercury on the other hand is almost entirely absorbed through the intestinal system. Little is known concerning the pulmonary absorption of organic mercury (USEPA, 1984).

An AIS (Acceptable Intake Subchronic for the oral route of exposure) has been recommended at 2.8×10^{-4} mg/kg/day for alkyl mercury and 2.0×10^{-3} mg/kg/day for inorganic mercury. An AIC (Acceptable Intake Chronic oral route) has been recommended at 3.0×10^{-4} mg/kg/day for alkyl mercury and at 2.0×10^{-3} mg/kg/day for inorganic mercury. A TLV has been established at 0.01 mg/m³ for aryl and inorganic compounds and .05 mg/m³ for alkyl vapor.

There is no data regarding mercury and its carcinogenic effects on humans.

6.3.4.3 Nickel. Nickel can be found in all areas of the environment, including plants and animals eaten by man. Minute quantities of nickel have been found to be essential to humans. High levels of nickel and nickel compounds are toxic. The target organ for nickel toxicity in humans is the lung. Toxic effects on the lung following inhalation exposures include an increased risk of lung cancer, an increased likelihood of developing asthma, as well as an increased susceptibility to pulmonary malfunctions. Pulmonary effects may be due to the effect of nickel on the immune system.

Only one fatal case has been reported following nickel ingestion. A 2 1/2 year old child died following ingestion of 15 grams of nickel sulfate crystals (3.3 g Ni), which is equivalent to a dose of 220 mg/kg of body weight. In a study involving rats, a dose of 5 mg/kg/day resulted in

a slight increase in white blood cell counts and a dose of 35 mg/kg/day resulted in a significant increase. In a teratogenicity study of nickel chloride in mice, no effects were observed at 500 ppm but a dose of 1,000 ppm resulted in maternal weight loss, a reduction in mean birth weight of pups and increased incidence of spontaneous abortions. Although all nickel compound have not been studied, nickel or its compounds do not appear to be carcinogenic via the oral route.

Approximately 2.5 to 5.0% of the general population may experience skin allergies following continued dermal contact with nickel. Sensitization may result from frequent skin contact with nickel containing and nickel-plated consumer products. Once sensitized, even minimal exposure will result in dermatitis. Sufficient data is not available to develop dose-response relationships.

6.3.4.4 Bis(2-ethylhexyl)phthalate. DEHP is a widely used plasticizer. It is a component of a wide variety of products made from polyvinyl chloride (PVC), including blood bags and surgical tubing.

DEHP has been reported to cause liver damage, testicular degeneration, teratogenic effects and cancer in animals. There are no specific studies on DEHP toxicological impacts in humans. DEHP is considered to have a relatively low acute toxicity. Oral LD₅₀ values include 26.0 g/kg in rats and 34.0 g/kg in rats and 34.0 g/kg in rabbits. A dermal LD₅₀ of 10 g/kg is given for the guinea pig.

Chronic toxicity of DEHP in animals is shown in several studies. A group of guinea pigs was fed a diet of 400 and 1300 ppm of DEHP for a period of a year. No treatment-related effects were observed in mortality, body weight, kidney weight or gross pathology of the liver, but increases in relative liver weights were observed in treated groups of females. Testicular atrophy was observed in male rats fed DEHP in the diet at 12,500 ppm for 13 weeks and seminiferous tubule degeneration of the testes was observed in male rats fed 12,000 ppm DEHP in a two-year study. Dose-related skeletal abnormalities and reduced fetal weight were reported in rats administered DEHP by intraperitoneal injection at a level

of 5 ml/kg on days 5, 10 and 15 of gestation. Bis(2-ethylhexyl)phthalate has not been shown to be mutagenic in most microbial in vitro and in vivo systems and in mammalian assay systems.

DEHP was found to be carcinogenic to both rats and mice fed diets containing 6,000 or 12,000 ppm DEHP (rats) and 3,000 or 6,000 (mice) for 103 weeks. An increased incidence of hepatocellular carcinoma was observed in high dose (6,000 ppm) male and high dose (6,000 ppm) female mice and high dose (12,000 ppm) female rats. A dose-related trend was observed and metastasis of hepatocellular carcinomas was observed in the lungs of several treated mice of both sexes.

The LC_{50} values for freshwater aquatic life range from 1.0 to 11.1 mg/L for Daphnia magna, and were greater than the highest value tested for the midge, scrod and bluegill (18 mg/L, 32 mg/L and 770 mg/L, respectively). Reproductive impairment was found at 3 ug/L in a chronic toxicity test with Daphnia magna. A chronic toxicity of 8.4 ug/L was reported for rainbow trout.

6.3.4.5 Arsenic. Arsenic is a ubiquitous element in the crust of the earth. Elemental arsenic is used primarily in metallurgy and glass manufacturing. Of greater toxicological concern are the oxides and salts of As^{+3} (arsenites) or As^{+5} (arsenates). In general, arsenites are several times more toxic than arsenates and soluble arsenic compounds are more toxic than insoluble compounds.

The Carcinogen Assessment Group of the U.S. EPA has classified arsenic as a Group A - Human Carcinogen based on sufficient evidence indicating that inorganic arsenic compounds are skin and lung carcinogens in humans. Several epidemiological studies have concluded that ingestion of drinking water containing arsenic causes skin cancer or cancer of internal organs. Although a relationship has been suggested, there is not enough evidence available to develop a dose-response model. There is inadequate evidence to determine the carcinogenicity of arsenic compounds in animals.

The U.S. EPA is currently reviewing the epidemiologic studies which led to the classification of inorganic arsenic as a human carcinogen as well as other related health effects data. One particular study done in Taiwan is under particular scrutiny because the original study included risk estimates one order of magnitude lower than those developed by the EPA. In addition, population differences between Americans and Taiwanese, such as diet, ethnicity and life expectancy may reduce the validity of the application of such a study across cultures. (Draft Special Report on Ingested Inorganic Arsenic: Skin Cancer; Nutrition Essentiality, Prepared for the Risk Assessment Forum, U.S. Environmental Protection Agency, November 1987).

Arsenic is a natural constituent of some foods, including seafood, pork and salt. The average daily intake is about 900 ug, most of which is ingested in food and water. Arsenic may be a possible, although unproven, nutritional requirement in animals. There is no specific information available on the essentiality of arsenic in humans (Draft Special Report on Ingested Inorganic Arsenic, 1987). The average concentration in adults is 20 mg, which is stored primarily in the liver, the gastrointestinal tract, the kidney and the lungs (Glance et al, 1986). Absorption of arsenic is primarily through inhalation or ingestion. In the gastrointestinal tract, absorption is governed by the solubility of the specific arsenic compound and the dosing rate. Absorption in the respiratory tract is governed by the specific chemical compound and the particle size.

Acute symptoms from high oral doses of arsenic include severe gastrointestinal disturbances with vomiting and diarrhea, impaired hematopoiesis, renal and hepatic necrosis and general vascular collapse leading to shock, coma or death. Oral LD₅₀ values for trivalent arsenic compounds range from about 10 to 300 mg/kg. The lethal dose in humans has been estimated to be 0.6 mg/kg/day or higher.

Chronic arsenic poisoning is initially characterized by malaise and fatigue. Further exposure may result in gastrointestinal disturbances, hyperpigmentation and peripheral neuropathy. Other symptoms include anemia, basophilic stripping, red cell disruption, decreased red cell

production and leukopenia (Doull et al, 1980). Arsenic induced skin lesions resulting from ingestion of arsenic are of special concern because these may develop into squamous cell or basal cell carcinomas. These forms of nonmelanoma skin cancer are generally not fatal.

6.3.4.6 Benzene. Benzene is a volatile organic (monocyclic aromatic) compound that is on the USEPA priority pollutant list. It is extremely toxic to human via ingestion, inhalation and dermal exposure. According to the International Agency for Research on Cancer (IARC), the available epidemiologic data provide sufficient evidence that benzene is carcinogenic to humans upon chronic exposure. It is also an animal carcinogen and is classified as an experimental mutagen and teratogen. Noncarcinogenic health effects include central nervous system and immunological effects, bone marrow depression (hematotoxin), as well as a strong irritant effect locally.

In mutagenicity bioassays, benzene tested negative in the Ames assay (bacterial cells) but caused decreased DNA synthesis in animal bone marrow and cultured human cells. In inhalation studies with test animals (i.e., rat, rabbit, mouse, amphibian), benzene caused mutagenic events. Negative reproductive effects have been reported from a subcutaneous injection study testing acute toxic doses on pregnant mice. Gavage administration in rats caused an increased incidence of leukemia and tumors of the oral cavity and skin, while in mice there was an increased incidence of tumors of the lung, ovaries and mammary gland. Thymic lymphomas were detected in mice administered 300 ppm benzene via inhalation. In humans, chronic exposure to benzene has been associated with bone marrow depression. The compound is a known leukemogen. Toxic central nervous system effects have been documented upon ingestion of 130 ppm benzene. The cumulative action of benzene is strong; daily exposure to concentrations less than 100 ppm can cause damage if continued over a protracted period. The Preliminary Protection Concentration Limit (PPCL) for chronic exposures is 0.66 ug/l and is based on a 10^{-6} Unit Cancer Risk level. The 10^{-6} risk level indicates there would be an increase of one case of cancer per one million people during a 70-year lifetime exposure to the carcinogenic agent at a given concentration. Effective July 8, 1987, EPA promulgated a Maximum

Contaminant Level (MCL) of 0.005 mg/l for benzene (152 Fed. Reg. 25690-25717, July 8, 1987). The ambient water quality criteria for protection of human health from ingestion of contaminated waters is set at 0.67 ug/l (10^{-6} risk level).

6.3.4.7 Trichloroethylene. TCE is a commonly used solvent for extraction and degreasing processes. It is also commonly used in the dry-cleaning industry. TCE is classified as a halogenated aliphatic hydrocarbon. It has a bioconcentration factor (BCF) of 16 in bluegill (Lepomis macrochirus). ACGIH has recommended a TWA of 50 ppm. NIOSH (1985) recommends an exposure limit of 100 ppm. Research indicates that 80-100% of ingested TCE is absorbed from the gastrointestinal tract in rats. Absorption through the lungs is rapid (USEPA, 1984). EPA has established an MCL of 0.005 mg/l for TCE.

Casarett et al (1980) reports that overexposure to TCE produces central nervous system depression including mental confusion, incoordination and insomnia. Other effects noted include increased liver and kidney weights, severe changes in the cerebellum and changes in the Purkinje cell layers of dogs. USEPA (1984) reports acute toxicity effects in mice through oral application, of decreased body weights, increased liver and kidney weights, and increased levels of ketone and protein in the urine at doses of 660.2 mg/kg/day for males and 793.3 mg/kg/day for females. Research on exposure through inhalation also indicates decreases in body weight in rats and mice. There is little information regarding the chronic effects of TCE. Research indicates that the only teratogenic effects following inhalation exposure to TCE vapor in mice are reduced fetal body weight, reduced body size and delayed skeletal ossification (USEPA, 1984).

Epidemiologic studies on the carcinogenicity of TCE inhalation have shown conflicting results. Bioassays utilizing both oral and inhalation exposure to mice have indicated a dose-response relationship between levels of TCE and the incidence of carcinoma. Research has shown that inhalation of TCE vapor produces pulmonary adenocarcinomas and lymphomas

in female mice and hepatocellular carcinomas in both male and female mice. Based on this evidence, trichloroethylene is classified as a Probable Human Carcinogen (Group B2).

6.3.4.8 Asbestos. Asbestos is a generic term applied to a large group of hydrate silicates containing metal cations such as sodium, magnesium, calcium or iron. Asbestos can be separated into two mineral groups, serpentine and amphibole. Chrysotile, the most important commercial asbestos, is a serpentine. The amphiboles include actinolite, amosite, anthophyllite, crocidolite and tremolite.

Research indicates that the toxicity and carcinogenicity of asbestos is associated with the nature, size and sometimes geographic origination of the fibers. The toxic action of asbestos occurs as a result of the mechanical penetration of tissue barriers by fibers. Distribution of fibers from entry points to other tissues is aided by phagocytic uptake of macrophages and monocytes and subsequent movement through the lymphatic system or bloodstream.

Asbestosis in humans is characterized by diffuse interstitial fibrosis, calcification and fibrosis of the pleura, bronchogenic carcinoma and mesothelial tumors. The exact mechanism of systemic initiation by asbestos fibers is unknown.

There is little data on the subchronic effect of oral exposure to asbestos by humans. The one study of subchronic inhalation exposure to humans indicated airflow abnormalities following an intense 5-month exposure to asbestos. Inhalation exposure to rats resulted in considerable changes in alveolar epithelial and interstitial cells. Exposure of guinea pigs to 30,000 to 37,600 particles/m³ for 8 hours/day, 5 days/week for 49 weeks resulted in pulmonary fibrosis, interstitial pneumonitis, cubical metaplasia of the epithelium of the alveolar ducts and cor pulmonale (USEPA, 1984).

Most toxic effects associated with asbestos are chronic in nature, requiring long periods of time for expression of effects. Most chronic effects are carcinogenic responses. The major noncarcinogenic chronic

effects in humans produced as a result of inhalation in humans is progressive pneumoconiosis. Other noncarcinogenic effects include pulmonary dysfunction, diffusional defects and airway obstruction.

There is no data regarding the teratogenicity of asbestos. Asbestos exposure has been associated with bronchogenic carcinoma, mesothelioma, and gastrointestinal cancer in humans. Based on evidence of associated cancers in humans, supported by animal bioassay data, asbestos is classified as a Group A substance (Human Carcinogen) (USEPA, 1984).

6.3.5 Environmental Receptor Analysis

6.3.5.1 Human Population. The Millington Site is located in a suburban portion of Morris County in north-central New Jersey. Millington has a population of approximately 7800. The site is located adjacent to a lease office storage space complex containing twenty-one firms. These firms collectively employ 150-200 personnel.

In addition, within a one mile radius of the site, there are approximately 200 residences containing up to 640 residents. Other exposed human areas include the Millington train station and a local school. The Millington train station is located adjacent to the site, which an approximately 252 people frequent daily during peak rush hours. Further, there is an eatery located at the train station which serves approximately 300 people per day. The local school is approximately one mile from the site and contains 243 students.

Records at the Millington Tax Office indicate that there are approximately 125 private potable wells within a 5 mile radius of the site. Approximately 30 wells are within a one mile radius. All wells are upgradient of the site. City-supplied water is provided by the Commonwealth Water Company, and the source for their water is the Passaic River. The nearest water intake to the site is approximately 10 miles downstream of the Site. Surface water samples were collected from that point and are labeled SW-22.

Additional conversations with the Millington Township Tax Assessor indicates that the presence of the asbestos mound at the site is having no effect on property values in the vicinity. The welfare concern of the site with respect to on-site workers and the surrounding public will be addressed in the risk characterizations. While surrounding residents are aware of the presence of contamination at the Millington Site, there is no evidence of much public media concern.

6.3.5.2 Floral Receptors. The uptake of nutrients and water through plant roots offers a direct pathway for contaminants distributed in soil or suspended in groundwater. Provided these contaminants are able to pass through the root epidermis, they will move via symplastic or apoplastic pathways through the roots, and will eventually be transported and stored in aboveground plant parts such as stems, leaves and fruits. Passage into the roots is dependent on the type of compound, pH of the surrounding soil, type of soil and its state of hydration. In the plant, contamination can pose an acute threat to the plant itself, or a threat to herbivores feeding on contaminated plant parts. Herbivorous activity then offers the threat of contaminant intrusion into the food chain and possible ecological repercussions at a higher trophic level.

The Millington Site is divided into two distinct vegetative units. They include an old field unit upgradient of the asbestos mound and in the center of the site. This area is dominated by short perennial grasses and annual herbaceous forbs. These plants are characterized by shallow root systems. The effects of contaminants at any depth below approximately three feet would be negated by the surficial nature of these fibrous root systems.

The other type of vegetative unit is a hardwood riparian complex along the Passaic River. Hardwood trees include Black Oak (Quercus velutina), Gray Birch (Betula alleghaniensis) and Sycamore (Platanus accidentalis). The understory includes Eastern Redcedar (Juniperus virginiana) and Common Sumac (Rhus glabra). While actual density determinations were not made, understory vegetation is moderately dense and overstory boles are evenly spaced. The possible environmental threat to these plants is of greater magnitude because of a deeper, more wide spread root system.

There is not enough information to accurately define a relationship between soils and the terrestrial plants at the site. Only two surface soil samples were taken (one in each general vegetative unit). Thus, there is not sufficient information available to define the surficial extent of contamination and the possible extent of plant exposure. Of the two samples taken, mercury and nickel are the predominant chemicals of concern. Nickel is taken up by plants, but not readily. Uptake is usually dependent on soil pH. Basic soils (6.5 pH and greater) will generally bind nickel, making it unavailable to plants. Soil pH for the Millington Site was not determined.

Mercury uptake is dependent on the type of mercury present. Mercury is not readily taken up by plants unless it is in the methylmercuric form. There was no analysis performed to determine the levels of methylmercury found at the Millington Site. There are low levels of benzene in the old field vegetative unit and bis(2-ethylhexyl)phthalate and trichloroethylene in the riparian unit. The scientific literature contains little information on the effects of organic compounds and their uptake on plants.

The final chemical of concern, asbestos is not expected to pose any threat to the vegetation. As a mineral in fiber form, there is no capacity to introduce asbestos into a plant system. Therefore, asbestos does not pose a threat to the vegetation.

The primary gauge of environmental impacts on vegetation is physiological appearance and reproductive hardiness. Field observations of the plants on site indicate no sign of stress or loss of vigor. Therefore, it is not believe that the chemicals of concern are effecting the terrestrial vegetation.

6.3.5.3 Faunal Receptors. The impacts of chemicals of concern on terrestrial fauna occur via the same pathways as seen in human populations. Fauna are environmental receptors, with toxic effects expressed both in acute and chronic form. For some chemicals, the chronic expression includes bioaccumulation and biomagnification as a chemical of concern moved up the food chain.

Field surveys to describe the terrestrial vertebrate and invertebrate populations found at the Millington Site were beyond the scope of work of the approved work plan. However, based on a review of habitat types, and direct and indirect observations during the field activities, a baseline understanding of the wildlife on site was derived. Site wildlife includes mammals: white-tailed deer (Odocoileus virginianus), red fox (Vulpes vulpes), Eastern cottontail (Sylvilagus floridanus), gray squirrel (Sciurus carolinensis), striped skunk (Mephitis mephitis) and opossum (Didelphis virginiana); birds (Downy woodpecker (Dendrocopos pubescens) and black-capped chickadee (Parus atricapillus); and various reptiles and amphibians. Any commensal animals, if present, would probably include the black rat (Rattus rattus) and the house mouse (Mus musculus). Other organisms not observed, but expected to inhabit the site would be various rodent species of the family Cricetidae. Various species of finfish would be expected in the Passaic River.

All organisms described have the potential to serve as receptors for the chemicals of concern. The introduction of these chemicals, and the subsequent expression of their toxic effects, can either occur as the result of direct contact or through an indirect manner such as ingestion of contaminated food items (seeds, leaves, detritus, carrion or garbage). Regardless of the pathway, the toxic effects are dose related and directly tied to the level of concentration of the contaminant. These levels are somewhat mitigated by the matrix effect as described by Hawley (1984). The tendency of an inert material, such as soil, to bind and essentially "dilute" contaminants, would result in a less effective concentration level of the material.

6.3.5.4 Food Chain Analysis. Movement through the food chain is characterized by the transfer of contaminants from trophic level to trophic level. Herbivores feeding on contaminated plants can be expected to initiate basic biogeochemical cycling of contaminants. Carnivores then feed on herbivores, picking up the contaminants, then completing the cycle back to the soil through carcasses or waste material. At the Millington

Site, the cycle is blocked because the chemicals of concern are not easily taken up by plants or readily bioaccumulated. Therefore, it is not expected that these chemicals are readily introduced into the food chain.

6.3.5.5 Endangered/Threatened Species. The U.S. Fish and Wildlife Service lists two species, the Bald Eagle (Haliaeetus leucocephalus) and the Peregrine Falcon (Falco peregrinus) that are endemic to the region. Due to the nature of the site, neither would be expected to be present on, or effected by, the site. The State of New Jersey (NJDEP) lists 26 endangered or threatened birds, 7 endangered or threatened amphibians, and 10 endangered or threatened reptiles that are found in the region. None would be expected to be present on, or effected by, the site.

6.3.6 Exposure Point Concentrations and Risk Characterization. As a regulated Superfund site, guidance material for use on Superfund sites was utilized in assessing the Millington site. Risk evaluations were made utilizing assumptions as conservative as possible while still being realistic in order to overestimate risk.

6.3.6.1 Selection of ARARs. Projected exposure point concentrations of Indicator Chemicals must be compared to "applicable or relevant and appropriate requirements" (ARARs), as defined by the National Contingency Plan (NCP). "Other criteria, advisories, and guidance" may also be used if pertinent to site exposure conditions (Superfund Public Health Evaluation Manual or PHEM, USEPA, October 1986). These ARARs govern the extent of site cleanup by providing either actual target concentrations or a basis for calculating such concentrations. The determination of exactly which ARARs are appropriate to a particular site should be made on a site-specific basis. Potential ARARs, such as Safe Drinking Water Act Maximum Contaminant Levels (MCLs), are not necessarily appropriate for every site. Table 6.3-4 lists potential ARARs.

6.3.6.2 Development of Risk Characterizations. The calculation of risk levels for each chemical of concern provides a relative assessment of the extent of the possible public health and environment threat presented by the site. Risks are calculated for carcinogenic and noncarcinogenic chemicals using methodologies specific for each exposure pathway in the

PHEM. For the carcinogens, HART compared calculated risk levels to a risk standard of 1.0×10^{-5} (i.e. the risk of 1 person in 100,000 contracting cancer based on a seventy year lifetime exposure). This comparison was made because EPA's CERCLA policy states that the target risk resulting from exposure to carcinogens at a Superfund Site may range from 10^{-4} to 10^{-7} . The risk level was calculated by using time weighted body dose levels, standard toxicity factors for each chemical and site concentrations. More detailed methodologies for each exposure pathway are presented in the following chapters.

For the noncarcinogens, body dose levels were compared to standard acceptable chronic intake levels. If the ratio was one or less, then the risk was considered to be acceptable. Again, specific methodologies for each exposure pathways are presented in the following chapters.

Risk characterizations were developed for direct contact to on-site surficial soils, ingestion of surficial soils, direct contact with surface water and ingestion of contaminated fish. Risk characterizations were developed for most probable case scenarios and realistic worst case scenarios. Most probable case case scenarios were based on the representative value for each chemical in a media. Realist worst case scenarios were based on the highest concentration found.

6.3.6.2.1 Direct Contact to On-Site Soil. The presence of contaminants in surface soils on the site provides the possibility of human exposure via direct contact. The types and amounts of contaminants found on the site are presented in Table 6.2-3.

The following equation was used to estimate body dose levels through direct contact with soils containing chemicals of concern:

$$\text{Body dose level (mg/kg/day)} = C * A * Ab * \frac{1}{BW} * M * \frac{E * F}{365 \text{ days}} * \frac{Y}{70 \text{ years}}$$

where: C = concentration (mg/kg)
 A = amount of soil contacted (kg/day)
 Ab = percent of chemical absorbed

TABLE 6.3-4
POTENTIAL ARARs FOR THE MILLINGTON SITE

<u>Chemical Contaminant</u>	<u>Safe Drinking Water Act MCLs (mg/l) (a)</u>	<u>WQC Adjusted For Fish and Drinking Water (b)</u>	<u>WQC Adjusted For Drinking Water Only (c)</u>	<u>Proposed MCLG's (mg/l)</u>	<u>NJDEP Guidelines for Contaminants in soil (e)</u>	<u>NJDEP Guidelines for Contaminants in groundwater (e)</u>
cadmium	0.01	10 ug/l	10 ug/l	0.005	3 mg/kg	10 ug/l
mercury	0.002	144 ng/l	10 ug/l	0.003	1 mg/kg	2 ug/l
nickel	---	13.4 ug/l	15.4 ug/l	---	100 mg/kg	---
di(2-ethylhexyl)phthalate	---	15 mg/l	21 mg/l	---	---	---
arsenic	0.05	2.2 ng/l	25 ng/l	0.005	20 mg/kg	50 ug/l
benzene	0.005	0.66 ug/l	0.67 ug/l	---	---	---
1,1-dichloroethylene	0.005	2.7 ug/l	2.8 ug/l	---	---	---
asbestos	---	30,000 fibers/l	30,000 fibers/l	7.1E+06 fibers/l	---	---
total volatiles	---	---	---	---	1 mg/kg	10 ug/l
total base neutral extractables	---	---	---	---	10 mg/kg	50 ug/l
total acid extractables	---	---	---	---	10 mg/kg	50 ug/l
total petroleum hydrocarbons	---	---	---	---	100 mg/kg	1000 ug/l

Notes:

- a) Maximum Contaminant Levels (MCLs) are enforceable standards listed in USEPA 540/1-86/060 Superfund Public Health Evaluation Manual.
- b) Ambient Water Quality Criteria (WQC) for the protection of human health via the ingestion of fish and drinking water are listed in USEPA 540/1-86/060 Superfund Public Health Evaluation Manual.
- c) Ambient Water Quality Criteria (WQC) for the protection of human health via the ingestion of drinking water (10^{-6} risk level) only are listed in USEPA 540/1-86/060 Superfund Public Health Evaluation Manual.
- d) Proposed Maximum Cleanup Level Guidelines (MCLGs) are proposed nonenforceable criteria based strictly on health considerations and are listed in USEPA 540/1-86/060 Superfund Public Health Evaluation Manual.
- e) NJDEP Guidelines of Contaminants in soil and groundwater are informal criteria used in evaluating possible cleanup requirements.

- BW = body weight (kg)
 F = frequency of contact (days)
 Y = exposure in a lifetime
 M = matrix coefficient effect or the fraction of a chemical that is available to be transferred to an exposed skin surface.
 E = exposure coefficient or the fraction of time that a person is actually exposed to the site.

For noncarcinogenic compounds, the last two terms in the equation drop out because the dose is not averaged over a lifetime. Table 6.3-5 summarizes the values used in the above equation for various exposure scenarios. Table 6.3-6 presents body dose level calculations and presents a comparison of those body dose levels to the appropriate potency factor. For carcinogens, the potency factor is listed in Exhibit A-4 of the Superfund Public Health Evaluation Manual. For noncarcinogens, the potency factor is the Acceptable Chronic Intake (AIC) value listed in Exhibit A-6 of the Manual.

Table 6.3-6 also presents risk characterization calculations. For carcinogens, a risk characterization of less than 10^{-5} is an acceptable risk. A risk characterization of one or less for noncarcinogens is considered acceptable.

6.3.6.2.2 Ingestion of Surface Soils. Determination of the risk from ingestion of soil is based upon the calculation of a risk factor and comparison of that factor to the 10^{-5} risk factor utilized in the dermal contact equation. The risk factors were formulated by multiplying the Lowest Acceptance Daily Dose (LADD) by the Unit Cancer Risk (UCR) (Risk = LADD X UCR). The LADD was formulated using the following equation.

$$\text{LADD (mg/kg/day)} = \frac{(\text{concentration}) (\text{amount soil}) (\text{absorption}) (\text{contact/})}{(\text{days per lifetime}) (\text{body weight})} \frac{(\text{ingested}) (\text{coefficient}) (\text{lifetime})}{(\text{body weight})}$$

The UCR was obtained from Exhibit A-4 of the PHEM.

TABLE 6.3-5

PARAMETERS USED IN CALCULATION OF BODY DOSE LEVELS FOR ON-SITE SOILS

<u>Parameter</u>	<u>Most Probable Case</u>		<u>Realistic Worst Case</u>	
	<u>Child</u>	<u>Adult</u>	<u>Child</u>	<u>Adult</u>
Frequency of Contact ^{1,2} (days/year)	3.25	4.06	7.5	8.12
Years of Exposure ³	5.0	5.0	7.0	10.0
Absorption Fraction ⁴				
VOCs	0.10	0.10	0.50	0.50
SVOCs, PCBs, Inorganics	0.01	0.01	0.10	0.10
Exposure Coefficient ⁵				
Direct Contact	0.40	0.10	0.40	0.10
Ingestion	0.40	0.10	0.40	0.10
Avg. Wt. over Exposure Period (kg) ⁶	35	70	35	70
Surface Area of Exposed Skin (cm ²) ⁷	940	908	1880	1815
Maximum amt. of soil that can adhere to skin (kg/cm ²) ⁸	1.45E-06	1.45E-06	2.77E-06	2.77E-06
Amt. of soil contacted (kg/day)	1.36E-03	1.32E-03	5.21E-03	5.03E-03
Matrix Coefficient Effect ⁹	50%	50%	50%	50%
Exposure Point Concentration	See Table 6.3-6			

Footnotes:

1. Frequency of contact refers to the duration of exposure to the soil containing chemicals of concern. Eight hours of exposure is assumed to be equal to one day of exposure.

TABLE 6.3-5 (CONTINUED)

PARAMETERS USED IN CALCULATION OF BODY DOSE LEVELS FOR ON-SITE SOILS

2. Based on observations during field investigations, it is known that exposure to on-site soils is very small, especially during weekdays. There is no foot traffic in the area, especially downgradient of the site. It has been observed that workers park vans and delivery trucks upgradient approximately 35 yards from TB-906. These individuals were used in considering exposure scenarios for adults. It was assumed that for the most probable case (adult), a worker would be exposed for 15 minutes per day, 5 days per week, for 26 weeks per year. Therefore, actual exposure is $0.25 \text{ hrs/day} \times 5 \text{ days/wk} \times 26 \text{ wks/yr} = 8 \text{ hrs/day}$ for 4.06 days per year. Under the Realistic Worst Case Scenario (Adults), daily exposure was 0.5 hours per day. With all other parameters the same, this is equal to 8.12 days per year. While there is no evidence or observation to support this, it was assumed that children could play on site during the weekends. It was assumed, for the Most Probable Case, that a child would play on site 2 hours per day, 1 day per week for 13 weeks per year. Therefore, actual exposure is $2 \text{ hrs/day} \times 1 \text{ day/wk} \times 13 \text{ wks/yr} = 8 \text{ hrs/day}$ for 3.25 days per year. Under the Realistic Worst Case, it was assumed exposure would be 4 hours per day, 1 day per week, for 15 weeks per year. Therefore, actual exposure is $4 \text{ hrs/day} \times 1 \text{ day/wk} \times 15 \text{ wks/yr} = 8 \text{ hrs/day}$ for 7.5 days per year.
3. For the Most Probable Case, children were assumed to be exposed for 5 years and adults for 5 years. For the Realistic Worst Case, children were assumed to be exposed for 7 years and adults for 10.
4. Although current EPA guidelines state that in the absence of dermal absorption factors for specific compounds, a value of 100% can be used, this is an over-estimation even under absolute worst case conditions. A dermal absorption range of 10-50% was assigned to volatile organic compounds (VOCs), and a range of 1-10% was assigned to semi-volatile organic compounds (SVOCs), PCBs and inorganics. The low end of the range was used for the most probable case scenario, and the high end of the range was used for the realistic worst case scenario.
5. For direct contact, it was assumed that actual exposure time on site for adults would be 10% of the frequency of contact. For children it was assumed to be 40%. For ingestion of contaminated soils, it was assumed that adults ingested soils only 10% of the time on site, and children ingested soils 40% of the time on site.
6. An average child was assumed to weight 35 kg; an average adult was assumed to weight 70 kg.

TABLE 6.3-5 (CONTINUED)

PARAMETERS USED IN CALCULATION OF BODY DOSE LEVELS FOR ON-SITE SOILS

7. According to the Superfund Exposure Assessment Manual (Jan., 1986) the average adult has approximately 13,150 cm² of skin surface area, and an average child has approximately 9,400 cm². For the most probable case, it was assumed that 10% of a child's skin surface area would come in contact with soils containing chemicals of concern (10% x 9,400 = 940)); for the realistic worst case, it was assumed that 20% of a child's total skin area would come into contact with soils containing chemicals of concern. For adults, exposed skin in contact with or soils containing chemicals of concern was assumed to be 5% for the most probable case and 10% for the realistic worst case.
8. According to the Superfund Exposure Assessment Manual (Jan., 1986), clay minerals may adhere to hands at 2.77 mg of clay/cm² of skin. This value was used as the maximum amount of soil that can adhere to skin, for both children and adults for the realistic worst case scenario. According to the Manual, commercial potting soil adheres to hands at 1.45 mg/cm². This value was used as the maximum amount of soil that can adhere to skin for both children and adults for the most probable case. According to the Manual (p.6-8), both of these values should be used to generate an exposure range.
9. According to Hawley (1985), due to the matrix effect, only 15% of the concentration of a chemical in soil is available to be transferred to an exposed skin surface. The remainder is tightly bound to soil particles. EPA has reported that this value is too low so a more conservative value of 50% was chosen to allow for a higher level of chemical within the soil to be exposed to skin surfaces.

TABLE 6.3-6

DIRECT CONTACT RISK CHARACTERIZATION CALCULATIONS:
ON-SITE SOILS

Direct Contact Calculations

Body Dose Level = $C * A * Ab * (1/BW) * ((F * E)/365 \text{ days}) * (Y/70 \text{ years})$
(mg/kg/day)

Where: C = Exposure Point Concentration (mg/kg)
A = Amount of Soil Contacted (g/day)
Ab = Percent of Contaminant Absorbed
BW = Body Weight (kg)
F = Frequency of Contact (days)
Y = Exposure in a Lifetime
E = Exposure coefficient

For noncarcinogens, the last two terms of the equation drop out because the dose is not averaged over the course of a lifetime.

Parameter	<u>Most Probable Case</u>		<u>Realistic Worst Case</u>	
	<u>Child</u>	<u>Adult</u>	<u>Child</u>	<u>Adult</u>
Frequency of Contact (days/year)	3.25	4.06	7.5	.8
Years of Exposure	5.0	5.0	7.0	10.0
Absorption Fraction				
VOCs	0.10	0.10	0.50	0.50
SVOCs, PCBs, Inorganics	0.01	0.01	0.10	0.10
Exposure Coefficient	0.40	0.10	0.40	0.10
Avg. Wt. over Exposure Period (kg)	35	70	35	70
Surface Area of Exposed Skin (cm ²)	940	908	1880	1815
Maximum amt. of soil that can adhere to skin (kg/cm ²)	1.45E-06	1.45E-06	2.77E-06	2.77E-06
Amt. of soil contacted (kg/day)	1.36E-03	1.32E-03	5.2E-03	5.03E-03

TABLE 6.3-6 (CONTINUED)

Indicator chemicals	Exposure Point Concentration		Body Dose Level				Potency Factor (mg/kg/day)	Risk Characterization			
	Most Probable Case (mg/kg)(1)	Realistic Worst Case (mg/kg)(2)	Most Probable Case (mg/kg/day)		Realistic worst Case (mg/kg/day)			Most Probable Case		Realistic Worst Case	
			Child	Adult	Child	Adult		Child	Adult	Child	Adult
cinogens:											
arsenic	3.40E+00	3.40E+00	3.37E-10	5.01E-11	4.16E-08	7.65E-09	1.50E+01	5.04E-09	7.53E-10	6.24E-07	1.15E-07
EHP	3.10E-01	3.10E-01	3.07E-11	4.56E-12	3.79E-09	6.97E-10	6.84E-04	2.10E-14	3.13E-15	2.59E-12	4.77E-13
carcinogens:											
mercury	4.50E-01	8.00E-01	1.75E-07	8.46E-08	1.19E-05	5.75E-06	3.00E-04	5.83E-04	2.83E-04	3.97E-02	1.92E-02
nickel	2.17E+01	2.58E+01	8.45E-06	4.08E-06	3.84E-04	1.85E-04	1.00E-02	8.43E-04	4.09E-04	3.84E-02	1.85E-02
EHP	3.10E-01	3.10E-01	1.21E-07	5.83E-08	4.61E-06	2.23E-06	2.00E-02	6.04E-07	2.92E-07	2.31E-04	1.11E-04

This is the mean concentration of the compound detected in surface soil samples at the site, multiplied by the 50% matrix effect.

This is the maximum concentration of the compound detected in surface soil samples at the site, multiplied by the 50% matrix effect.

1. The exposure times were assumed to be identical to those used in the direct contact scenarios.
2. It was assumed that an adult would ingest contaminated soil only 10% of the time spent on the site. It was also assumed that a child would ingest soil only 40% of the time spent on site.
3. The adult would ingest 480 mg of soil per day, as estimated by Hawley, (1985). A child would ingest 50 mg of soil per day.
4. Adult body weight was assumed to be 70 kg. Body weight of children was assumed to be 35 kg.
5. In calculating days per lifetime, 70 years, the average lifespan for an adult male as presented by the Report of the Task Group on Reference Man (1984), was utilized.
6. The final assumption is that absorption of each chemical via ingestion is 100%. (This is a very conservative approach noting the type of chemicals and the matrix effect. However, these factors are impossible to estimate with any accuracy. Therefore the conservative approach is the most prudent.)

Table 6.3-7 summarizes the risk values for carcinogens found in the surface soil that have UCR values taken from Appendix A-4 of the PHEM. Additionally, calculations for risks associated with ingestion of contaminated soils are presented in Appendix I.

The risk attributable to ingestion of surface soils contaminated with noncarcinogenic compounds was determined by calculating the MDD for each chemical and comparing it to the ADI for each chemical. The MDD was calculated using the following formula:

$$\text{MDD (mg/kg/day)} = \frac{(\text{concentration}) (\text{amount soil ingested}) (\text{absorption coefficient})}{(\text{body weight})}$$

The ADI was obtained from Exhibit A-6 of the PHEM. If the ratio of the Maximum Daily Dose (MDD) over the Acceptable Daily Intake (ADI) was found to be one or less, there was no risk attributable to ingestion of that compound. If a risk ratio was greater than one, then the risk was deemed unacceptable. The assumptions and exposure times are the same as for ingestion of carcinogens. Table 6.3-7 summarizes the risk levels associated with each chemical.

Calculations for risks associated with the ingestion of soils containing potential compounds are found in Appendix I.

6.3.6.2.3 Ingestion of Contaminated Fish. While ingestion of contaminated fish caught in the area is not considered a major exposure route, it has been identified as a possible route. The daily intake of contaminants through fish was calculated based on procedures outlined in the PHEM. The values arrived at used the LADD and the MDD for carcinogenic and noncarcinogenic risks, respectively. For the carcinogens, risks were calculated by multiplying the Lowest Acceptable Daily Dose (LADD) by the Unit Cancer Risk (UCR). The LADD was calculated using the following formula:

$$\text{LADD} = \text{Concentration} \times \text{Bioconcentration Factor} \times \text{Human Intake Factor}$$

The bioconcentration factors were obtained from Exhibit A-1 of the PHEM and are listed in Table 6.2-3. The UCR for each chemical was obtained from Exhibit A-4 of the PHEM. If the risk calculations were found to be less than 1.0×10^{-5} , they were considered to be acceptable.

The following assumptions were made for the calculations:

- a. It was assumed that the absorption coefficient across the gastrointestinal tract was assumed to be 100%.

TABLE 6.3-7

RISK CHARACTERIZATION FOR THE INGESTION OF CONTAMINATED SURFACE SOIL

Indicator <u>Chemical</u>	<u>Most Probable Case Scenario</u>		<u>Realistic Worst Case Scenario</u>	
	<u>Child</u>	<u>Adult</u>	<u>Child</u>	<u>Adult</u>
Carcinogen:				
Arsenic	1.01E-08	6.05E-08	3.26E-08	2.00E-07
DEHP	3.86E-14	2.31E-13	1.82E-10	9.11E-13
Noncarcinogen:				
Mercury	4.29E-04	2.06E-03	8.09E-04	3.89E-03
Nickel	6.23E-04	2.99E-03	7.36E-04	3.54E-03

- b. It was assumed that the levels of contaminants in the river remain constant during the life of the individual. This is a major assumption and one not likely to occur.

The standard human intake factor was developed by assuming that the average individual would consume 32.4 grams fish/day. Dividing this value by the standard adult weight of 70 kg gives a standard human intake factor of .000463 kg fish/kg/day.

For the noncarcinogens, risk characterizations were based on dividing the Maximum Daily Dose (MDD) by the Acceptable Daily Intake (ADI). If the ratio was equal to or less than 1, then the risk was considered to be reasonable. The MDD was calculated using the following formula:

$$\text{MDD} = \text{Concentration} \times \text{Bioconcentration Factor} \times \text{Human Intake Factor}$$

The bioconcentration factors were obtained from Exhibit A-1 of the PHEM. The bioconcentration factor for bis(2-ethylhexyl)phthalate (130 l/kg) was obtained from An Exposure Risk Assessment, USEPA Office of Water Regulations and Standards, May 1981, EPA-440/4-81-020, page 4-17; and Handbook of Environmental Data on Organic Chemicals, Second Edition, Karel Verschueren, 1983, Van Nostrand Reinhold Company, Inc., page 578. The ADI for each chemical was obtained from Exhibit A-6 of the PHEM. All other assumptions from the ingestion of fish contaminated with carcinogens were considered to be the same.

Risk characterizations for the ingestion of fish are listed in Table 6.3-8. The actual calculations are presented in Appendix I.

6.3.6.2.4 Direct Contact With Surface Waters. Based on the apparent lack of recreational use of the Passaic River in the area of the site for swimming activities, dermal contact risks were assumed to be limited to fishermen. It was assumed that a fisherman (both adults and children) would be in the area for four hours per day, one day a week, 13 weeks per year for 35 years for adults and five years for children for the Most

TABLE 6.3-8

RISK CHARACTERIZATIONS FOR THE INGESTION OF CONTAMINATED FISH

<u>Indicator Chemical</u>	<u>Most Probable Case (1)</u>	<u>Realistic Worst Case (1)</u>
Carcinogens:		
Bis(2-ethylhexyl) phthalate ²	4.53E-06	4.53E-06
Noncarcinogens:		
Cadmium ²	7.28E+01	7.28E+01
Nickel	1.41E-01	1.83E-01
Bis(2-ethylhexyl) phthalate ²	• 3.31E-01	3.31E-01

Notes:

1. Because of the standard human intake value used in the derivation of intake as outlined in the PHEM, no differentiation in risk between adults and children was possible. Therefore, risks for adults and children were assumed to be the same.
2. Only one positive sample was obtained for each one of these compounds. Therefore, the Most Probable Case and Realistic Worst Case scenario were considered to be the same.

Probable Case. For the Realistic Worst Case, exposure time was assumed to be six hours per day, two days per week, 15 weeks per year for the same years of exposure previously discussed. It was also assumed that a fisherman would only expose the palm of one hand (181.5 cm² for adults, 94 cm² for children) for 10% of the time he was in the area fishing. Other assumptions associated with standard weights and lifetimes for children and adults are the same as for the ingestion of contaminated soil. Exposure would result in contact of 2 mg of water per cm² of body surface area. A dermal absorption coefficient of 1% was assumed for the Most Probable Case and 10% for the Realistic Worst Case.

To calculate risks for carcinogens, a Lowest Acceptable Daily Dose (LADD) was calculated and multiplied by the Unit Cancer Risk (UCR) value found in Exhibit A-4 of the PHEM. If the resulting value was less than 10⁻⁵, then the risk was deemed acceptable. The following formula was used for the calculation of the LADD:

$$\text{LADD} = \frac{(\text{concentration}) (\text{total body}) (\text{water/}) (\text{surface area}) (\text{surface}) (\text{Absorption}) (\text{contact/}) (\text{exposed}) (\text{area/day}) (\text{coefficient}) (\text{lifetime})}{(\text{days per lifetime}) \times (\text{body weight})}$$

To calculate risks for noncarcinogens, a ratio of the Maximum Daily Dose (MDD) over the Acceptable Daily Intake (ADI) was taken. If the ratio was 1 or less, then the risk was considered to be acceptable. ADI values were taken from Exhibit A-6. The MDD was calculated based on the following formula:

$$\text{MDD} = \frac{(\text{concentration}) (\text{surface area}) (\text{water/}) (\text{absorption}) (\text{exposed}) (\text{surface area/day}) (\text{coefficient})}{(\text{body weight})}$$

Table 6.3-9 lists the risk levels for direct contact with surface water. The actual calculations are presented in Appendix I.

TABLE 6.3-9

RISK CHARACTERIZATION FOR THE DIRECT CONTACT WITH SURFACE WATER

<u>Indicator Chemical</u>	<u>Most Probable Case Scenario</u>		<u>Realistic Worst Case Scenario</u>	
	<u>Child</u>	<u>Adult</u>	<u>Child</u>	<u>Adult</u>
Carcinogen:				
Bis(2-ethylhexyl) Phthalate	1.17E-11	7.63E-11	3.92E-10	2.63E-09
Noncarcinogen:				
Cadmium ⁽¹⁾	1.04E-05	1.01E-05	1.04E-04	1.01E-04
Nickel	3.49E-08	3.37E-08	4.51E-07	4.30E-07
Bis(2-ethylhexyl) phthalate ⁽¹⁾	2.95E-08	2.85E-08	2.95E-07	2.85E-07

Notes:

1. Because only one positive sample of this compound was obtained, there can be no differentiation between Most Probable Case and Realistic Worst Case.

6.3.6.3 Surface Water. Ingestion of fish in surface water and direct contact with surface water have a very slight possibility to exist as potential exposure pathways. Ingestion of surface water was considered to be such a remote possibility on even an occasional basis, that the development of a risk characterization is not necessary. The Passaic River does not directly supply drinking water to area homes. Residences in the area are either on the municipal water system or have upgradient potable wells. Swimming and boating in the area are nonexistent in the area of the site and fishing activities are minimal. Surface water is taken up into the Commonwealth Water Supply system approximately 10 miles downstream from the site. However, water passes through an extensive treatment system before it is made available to customers.

6.3.6.4 Groundwater. Since there are no groundwater users, or receptors downgradient of the site, no complete exposure pathway for groundwater exists. Since the pathway is incomplete, exposure point concentrations were not calculated and ARARs were not chosen.

6.3.7 Uncertainties in the Risk Management Process. The numerous worst case assumptions used in the exposure assessment are discussed above and will not be repeated. However, uncertainties and limitations inherent in risk assessment methodology must be fully understood to place quantitative risk assessment into an appropriate context. The following paragraph from the Superfund Public Health Evaluation Manual (USEPA, 1986, p. 80) summarizes the uncertainties inherent in the risk assessment process:

"It is emphasized that all estimates of carcinogenic risk and hazard index are dependent on numerous assumptions, and many uncertainties are inherent in the risk assessment process. Probably without exception, information on site history and site characterization data will be lacking in some areas. Most toxicity information is derived from animal studies, and reputable scientists disagree about how to interpret these data. A single toxicity parameter based on an animal study does not convey the route of administration of test doses of the suspect chemicals, the organ(s) in which the response occurred, or the severity of end points in the animal experiment used to calculate the dose-response relationship. Consequently, extrapolation to humans is a source of uncertainty. Many

toxicity studies are done at high doses relative to exposures associated with waste disposal sites; extrapolation from high to low doses also increases the uncertainty of risk numbers. Exposure modeling is based on many simplifying assumptions that add to the uncertainty. Often the quality or quantity of site-specific chemical monitoring data is inadequate. The additivity of toxicant risks and the additivity of doses of the same toxicant from different exposure routes are additional assumptions and additional sources of uncertainty. Consequently, the results of the baseline evaluation should not be taken as a characterization of absolute risk. An important use of these results is to highlight potential sources of risk at a site so that they may be dealt with effectively in the remedial process."

Dr. Renate Kimbrough, EPA Regional Director for Health and Risk Capability and formerly with the Centers for Disease Control, has stated that "although it is theoretically possible that some amount of a chemical may cause an effect, in practice it must be recognized that at very low concentrations, many competing elements come into play and the contribution of individual chemicals to adverse health effects may be of no consequence" (Kimbrough and Simmonds, 1986).

The results of quantitative risk assessment are not a measure of the actual or real cancer risk but a "plausible upper limit to the risk that is consistent with some proposed mechanisms of carcinogenesis.....The true value of the risk is unknown and may be as low as zero" (51 Federal Register 33998, 9/24/86) because a worst-case upper-bound risk scenario is unlikely to underestimate risk and likely to over estimate risk.

6.3.8 Risk Management Comparisons. The risk assessment process does not conclude with the production of a risk level, no matter how qualified that number may be. Risk assessment as performed by EPA, is composed of two parts: (1) the risk assessment, per se (i.e., the estimation of a risk level; and (2) the risk management decision.

Risk management "combines the risk assessment [the scientific input] with the directives of the regulatory legislation, together with

socioeconomic, technical, political, and other considerations, to reach a decision as to whether or how much to control future exposure to the suspected toxic agents [substances]" (EPA, Guideline for Carcinogen Risk Assessment, 51 Fed. Reg. 33993; Sept. 24, 1986).

"EPA believes that the appropriate inquiry is to what extent the risk posed by a pollutant should be minimized so the residual risk is reasonable for society to accept," (EPA, National Emission Standards for Hazardous Air Pollutants: Coke Oven Emissions From Wet-Coal Charged By-product Coke Oven Batteries, Proposed Rule and Notice of Public Hearing, 52 Fed. Reg. 13594; April 23, 1987, hereinafter "Proposed Coke Oven Regs"). EPA regulatory actions, therefore, "do not necessarily eliminate all public health risks but minimize those risks without causing unreasonable social or economic impacts" (EPA, Proposed Coke Oven Regs, 52 Fed 13586; April 23, 1987). The Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C.A § 9606-9657 (1987) (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), "does not direct EPA to eliminate all risk" (Letter from L. Thomas, EPA Administrator, to Honorable James J. Florio, May 21, 1987). EPA's CERCLA policy states that the target total individual carcinogenic risks resulting from exposure at a Superfund Site may range anywhere from 10^{-4} to 10^{-7} . Therefore, remedial alternatives being considered should be able to reduce total potential carcinogenic risks to individuals to levels within this range (Porter, July 9, 1987). The EPA Assistant Administrator (for Solid Waste and Emergency Response) recently affirmed this view in testimony before the US Senate Subcommittee on Superfund and Environmental Oversight (June 25, 1987): "We believe that a risk range of 10^{-4} to 10^{-7} individual lifetime risk for carcinogens provides adequate protection of human health and provides a sound basis for determining when requirements are relevant and appropriate." EPA often uses the 10^{-5} cancer risk level as an acceptable risk management level, even when large populations are exposed to this level of risk (EPA, Coke Oven Regs, 52 Fed. Reg. 13586 and 13594, April 23, 1987; EPA, Burning of Hazardous Waste in Boilers and Industrial Furnaces, Proposed Rule, 52 Fed. Reg. 16982 and 17036-37).

6.3.8.1 Present Risks. Table 6.3-10 lists those contaminants that pose a risk on-site. Specific pathways are discussed in the following sections.

6.3.8.1.1 Surface Soils. According to risk calculations, the site is not posing an unacceptable risk by either the ingestion pathway or direct contact with surface soils. Concentrations of contaminants are sufficiently low that, while the pathway is complete, there is no expression of risk based on the most probable case and realistic worst case scenarios for the site. The risk from direct contact to on-site surface soils is further mitigated by the thick vegetative and humic layer over the topsoil which prevents casual contact. In addition, there are very few individuals who actually frequent areas of the site containing chemicals of concern. Since few receptors are on-site at anytime, risks to individuals cannot be realized.

6.3.8.1.2 Subsurface Soil. Under present conditions, the site is not posing a risk via subsurface soil, because receptors are not associated with these soils. Therefore, no risks are associated with subsurface soil.

6.3.8.1.3 Surface Water. Surface water risk characterizations were calculated for the ingestion of contaminated fish and for direct contact with surface waters. No unacceptable risks were presented by the direct contact with surface waters.

Risk characterization calculations for both the Most Probable and Realistic Worst Case scenarios indicate that the ingestion of contaminated fish containing cadmium at levels equal to or exceeding 0.563 mg/l presents an unacceptable risk. A major qualification, however, should be noted for this risk characterization calculation. Cadmium was detected in only one sample in the initial sampling round. In both subsequent rounds of sampling, cadmium was not detected. Cadmium was also not detected in sediment samples. Therefore, it is logical to assume that the one value for cadmium was spurious and not truly indicative of concentrations of chemicals of concern in the river.

TABLE 6.3-10

CONTAMINANTS OF CONCERN WHICH POSE UNREASONABLE RISKS ON SITE

<u>Exposure Pathway</u>	<u>Most Probable Case Scenario</u>		<u>Realistic Worst Case Scenario</u>	
	<u>Child</u>	<u>Adult</u>	<u>Child</u>	<u>Adult</u>
Ingestion of Fish	Cadmium	Cadmium	Cadmium	Cadmium

6.3.8.1.4 Groundwater. No receptors for the ingestion of groundwater exist on or downgradient of the site. Therefore, no present risks are associated with this pathway.

6.3.8.2 Future Risks.

6.3.8.2.1 Surface Soils. Future risks due to direct contact with or ingestion of soils containing chemicals of concern are not expected to differ significantly between current and future conditions in the absence of site disturbances or visitor population. Therefore, unless any remedial actions occur or the number of people exposed to on-site soils increase, risks should remain acceptable.

6.3.8.2.2 Subsurface Soils. In the absence of site remediation, future potential risks would remain nonexistent. If a remedy such as excavation of soils were to occur, risks via direct contact or ingestion would be possible. This is because a greater soil area would be exposed and available for direct contact and because human activity in the area of concern would increase. The magnitude of the risk would depend on the extent of excavation, the remediation process and the number of workers involved in the excavation process. The use of personal protective gear during site remediation can be expected to reduce those risks.

6.3.8.2.3 Surface Water. Future risks via the surface water pathway are difficult to define because the contribution of chemicals of concern from the site to the river cannot be accurately quantified. It would not be expected that significant increases in risks would occur. The rationale for this is: while chemicals present at the site will maintain the possibility of transport via either surface runoff or groundwater for an extended period of time, contributions via these transport mechanisms (i.e. biodegradation) should currently be at a steady state level. Also, fate considerations for the chemicals of concern would play a part in the decrease of their presence at the site.

Potential increases in surface water contaminants could occur if specific changes in soil exposure and drainage patterns were to occur. This could be caused by remedial actions such as site excavation.

Excavation could result in changes in soil covering and provide more exposed soil that could be carried into the Passaic River.

Future potential risks could also increase if recreational uses of the river, such as boating, swimming and fishing, were to increase substantially.

6.3.8.2.4 Groundwater. The location and use of the site renders the placement of a potable well on or downgradient of the site highly unlikely. Furthermore, there is a well-developed municipal water system in the area. Therefore, no future potential risks are associated with the groundwater pathway.

7.0 CONCLUSIONS

7.1 Site Characterization

- Subsurface geology at the site consists of three units: a topsoil deposit, an asbestos waste deposit, and a silt/clay unit overlying weathered siltstone bedrock. The topsoil fill in addition to a vegetative cover act to control the environmental release of asbestos fibers from the asbestos waste deposit.
- Groundwater flow in the unconsolidated aquifer is westward towards the Passaic River.
- The Passaic River borders the western edge of the Millington Site and flows north to south in the vicinity of the site. Ten miles downstream of the site, the Commonwealth Water Company intakes surface water for use as municipal water supply following treatment.
- Volatile and base neutral organics and mercury are the primary constituents present in on-site soils. Mercury was detected in all three lithologic units at concentrations exceeding common range in natural soils. The presence of base neutrals is limited to the topsoil fill deposit and the lower silty/clay unit.
- Two volatiles (trichloroethene and benzene) and three dissolved metals (arsenic, mercury and nickel) were detected in on-site groundwater samples at concentrations exceeding either Maximum Contaminant Levels (MCLs) or USEPA Ambient Water Quality Criteria (AWQC) adjusted for consumption of drinking water only. Seven total metals were detected in on-site groundwater samples at concentrations exceeding MCLs or USEPA-AWQC. There are, however, no groundwater wells located downgradient of the site.

- The Passaic River, immediately downstream of the site, contained nickel, cadmium and asbestos in concentrations exceeding USEPA-AWQC. However, the relatively high value of cadmium detected in the first sampling round was not confirmed in subsequent sampling rounds.
- Asbestos concentrations were higher upstream than downstream of the site suggesting that there is an upstream source of asbestos.
- The sediments in the vicinity of the site contain base neutrals (primarily polynuclear aromatic hydrocarbons) and six metals (arsenic, chromium, copper, lead, mercury and zinc) at higher concentrations upstream than downstream of the Millington Site.

7.2 Stability of Asbestos Mound

- Analyses of slope stability of the asbestos mound are inconclusive. The laboratory results obtained in the additional engineering studies were not consistent enough to establish strength parameters for slope stability analysis.
- Surficial sloughing of part of the embankment has occurred in at least one location. This slough may be attributed to either static instability of portions of the embankment or to localized erosion of the embankment surface. The slough may act as a release mechanism for asbestos into the environment via erosion.

7.3 Risk Characterization

7.3.1 Present Risks.

- No present risks are associated with dermal contact or ingestion of surface soils containing contaminants of concern. Hypothetical exposure scenarios indicate that, based on the activity levels at the site, concentration levels for contaminants of concern are so low as to not present a risk.

- No present risks are associated with subsurface soils because there are no associated receptors.
- No present risks are associated with the direct contact of surface water. Contamination levels are so low that there is no expressed risk. Hypothetical calculations indicate that there is an unreasonable risk to children and adults for the ingestion of fish contaminated with cadmium. However, cadmium was only found in the initial round of three rounds of sampling. Therefore, the presence of cadmium is probably not representative of actual contamination in the Passaic River. There are no risks associated with the ingestion of surface water, because it is not directly used as a potable water supply.
- No present risks are associated with groundwater, because it is not used as a source of potable water on site. There are no potable wells at or downgradient of the site.

7.3.2 Future Risks.

Future risks are qualitatively derived risks to public health and the environment, drawn from the endangerment assessment.

- Without significant changes in site conditions or frequency of use, future risks associated with surface and subsurface soils are not expected to differ from present risks.
- Without significant changes in the use of the Passaic River or in the amount of soil eroding from the site, future risks associated with surface water are not expected to differ from present risks.
- No future risks are associated with groundwater. A well established municipal water supply system precludes the need to develop groundwater on-site.

REFERENCES

- Agency for Toxic Substances and Disease Registry. (ATSDR). 1987. Draft Toxicological Profile for Arsenic. U.S. Public Health Service (USPHS) in collaboration with USEPA.
- ATSDR. 1987c. Draft Toxicological Profile for Benzene. USPHS/USEPA.
- ATSDR. 1987g. Draft Toxicological Profile for Lead. USPHS/USEPA.
- Anderson, Peter W. and Faust, Samuel D., 1973, Characteristics of Water Quality and Stream Flow, Passaic River Basin Above Little Falls, New Jersey, U.S. Geological Survey Water Supply Paper 2026.
- Bohn, Hinrich, 1979, Soil Chemistry, John Wiley and Sons, Inc., New York, NY (329 pp.)
- Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. 1979. Water-related Environmental Fate of 129 Priority Pollutants. Vol. I. Office of Water Planning and Standards, Office of Water and Waste Management. U.S. EPA, Washington, D.C. EPA 440/4-79-029b.
- Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. 1979. Water-related Environmental Fate of 129 Priority Pollutants. Vol. II. Office of Water Planning and Standards, Office of Water and Waste Management. U.S. EPA, Washington, D.C. EPA 440/4-79-029b.
- Cooper, H.H., Bredehoeft, J.D. and Papadopoulos, S.S., 1967, Response of a Finite-Diameter Well to an Instantaneous Charge of Water, Water Resources Division, U.S. Geological Survey, Washington, D.C., Water Resources Research, Vol.3 No.1.
- Donigian, A., 1983, Rapid Response of Ground-Water Contamination Under Emergency Response Conditions, NTIS Report No. EPA-600/8-83-030 (147 pp.)
- Doull, J., C.D. Klaassen, M.O. Amdar. 1980. Toxicology: The Basic Science of Poisons. Macmillan Publishing Company, New York.
- Edwards, N.T. 1983. Polycyclic Aromatic Hydrocarbons (PAH's) in the Terrestrial Environment - A Review. Journal of Environmental Quality 12(4): 427-441.
- Ferris, J.G.D., 1962, Time Lag and Soil Permeability in Ground Water Observations, U.S. Army Corps. of Engineers, Waterways Exp. Sta. Bull. 36, Vicksburg, Miss.

- Fetter, C.W. Jr., 1980, Applied Hydrogeology, Charles E. Merrill Publishing Co., Columbus, Ohio, (488 pp.)
- Fischer, Joseph A., 1980, Environmental Geologic Traverse, in W. Manspizer Ed. Field Studies of New Jersey Geology and Guide to Field Trips.
- Freeze, Allan R. and Cherry, John A., 1979, Groundwater, Prentice Hall, Englewood Cliffs, New Jersey
- Glanze, W.D., K.N. Anderson, L.E. Anderson, et al. 1986. Mosby's Medical and Nursing Dictionary. C.V. Mosby Company, St. Louis.
- Hawley, J.K. 1985. Assessment of Health Risk from Exposure to Contaminated Soils. Risk Analysis 5:289-301.
- Hvorslev, M.J., 1951, D.B. Knowles, R.J. Brown, and R.W. Stallman, Theory of Aquifer tests, U.S. Geological Survey Water-Supply Paper 1536-E.
- Gill, Harold E. and Vecchioli, John, 1965, Availability of Ground Water in Morris County, N.J., U.S. Geological Survey Special Report No. 25.
- Miller, E.G., 1965, Effect of Great Swamp, New Jersey, on Stream Flow During Base-Flow Periods, U.S. Geological Survey Professional Paper 525-B.
- NIOSH Pocket Guide to Chemical Hazards. 1985. DHHS (NIOSH) Publication No. 85-114.
- Olsen, Paul E., 1980, Triassic and Jurassic Formations of the Newark Basin, in W. Manspizer Ed. Field Studies of New Jersey Geology and Guide to Field Trips.
- Papadopoulos, S.S., Bredehoeft, J.D. and Cooper, H.H., 1973, On the Analysis of "Slug Test" Data, U.S. Geological Survey, Tallahassee Florida, Water Resources Research, Vol. 9, No. 4.
- Peters, James A., 1981, Measurements of Fugitive Hydrocarbon Emissions from a Chemical Waste Disposal Site, APCA 81-41.1
- Porter, J.W. (EPA Assistant Administrator for Solid Waste and Emergency Response), Statement before the Subcommittee on Superfund and Environmental Oversight, Committee on Environment and Public Works, U.S. Senate, June 25, 1987.
- Safe Drinking Water Committee, 1977. Drinking Water and Health. National Academy of Sciences, Washington, D.C.
- Sax, N.I. 1984. Dangerous Properties of Industrial Materials. Vab Nostrand Reinhold Company, New York.
- Threshold Limit Values and Biological Exposure Indices for 1987-1988. American Conference on Governmental Industrial Hygienists

Turner, Bruce D., 1970, Workbook of Atmospheric Dispersion Estimates, USEPA.

U.S. Army Corps. of Engineers, 1987, Flood Protection Feasibility, Mainstream Passaic River, (Draft), Vol. 1 Main Report, Phase I-General Design Memorandum

U.S. Dept. of Interior, U.S. Geological Survey, 1981, Water Resource Data for New Jersey, Vol 1: Atlantic Slope Basins, Hudson River to Cape May, Water Year 1930.

USEPA. 1977. Air Quality Criteria For Lead. U.S. EPA, ORD, Washington, D.C. EPA 600/8-77-017.

USEPA. 1984. Health Effects Assessment for Arsenic. EPA/540/11-86-020.

USEPA. 1984. Health Effects Assessment for Lead. EPA/540/11-86/014.

USEPA. 1984. Health Effects Assessment for Asbestos. EPA/540/11-86/049.

USEPA. 1984. Health Effects Assessment for Cadmium. EPA/540/11-86/038.

USEPA. 1984. Health Effects Assessment for Mercury. EPA/540/11-86/042.

USEPA. 1984. Health Effects Assessment for Nickel. EPA/540/11-86/018.

USEPA. 1984. Health Effects Assessment for Trichloroethylene. EPA/540/11-86/046.

U.S. EPA Data Validation Work Group, 1985, Laboratory Data Validation Functional Guidelines For Evaluating Organic Analyses, Technical Directive Document No. HQ-8410-01

U.S. EPA Data Validation Work Group, 1985, Laboratory Data Validation Functional Guidelines For Evaluating Inorganic Analyses, Technical Directive Document No. HQ-8410-01

U.S. EPA Data Validation Work Group, 1985, Laboratory Data Validation Functional Guidelines for Evaluating Pesticides/PCB Analyses, Technical Directive Document No. HQ-8410-01

U.S. EPA, 1986, Superfund Public Health Evaluation Manual, Office of Emergency and Remedial Response, Office of Solid Waste and Emergency Response, Washington, D.C. (145 pp.)

U.S. EPA, 1986, Draft Superfund Exposure Assessment Manual, Office of Emergency and Remedial Response, Office of Solid Waste and Emergency Response, Washington, DC.

USEPA. 1987. Draft Special Report on Ingested Inorganic Arsenic: Skin Cancer; Nutritional Essentiality. EPA/625/3-87/013A.

U.S. EPA, 1983, Hazardous Waste Land Treatment, Office of Solid Waste and Emergency Response SW-874 (pp.273, Table 6.46).

Walton, William C., 1985, Practical Aspects of Groundwater Modelling,
National Well Water Association, Worthington, Ohio, (587 pp.)

Vecchioli, John, Gill, Harold E. and Lang, Solomon M., 1962, Hydrologic
Role of the Great Swamp and Other Marshlands in Upper Passaic River
Basin, Jour. AWWA.

Verschueren, K. 1983. Handbook of Environmental Data on Organic
Chemicals. Von Nostrand Reinhold Company, New York.